CCCCLXXI. NICKEL. *(l)*

CCCCLXXII. NITRE, *or* SALTPETRE. Nitre is a neutral salt composed of a peculiar acid, called *nitrous acid*, saturated with fixed vegetable alkali.

This salt has a saline and cooling taste, which is succeeded by another more disagreeable taste. It is easily soluble in water, but in much greater quantity in boiling than in cold water. It is consequently one of those salts which are more readily crystallized by cold than by evaporation. Therefore, if fine crystals of nitre are required, this salt must be dissolved in water, and heat must be applied, that the water may take up more salt than it can retain when it is cold. When this solution of nitre is allowed to cool, many crystals will be formed which will be so much larger and finer, as the quantity of salt operated upon at the same time has been greater, and as the cooling of the liquor has been slower.

Crystals of nitre are oblong solids, the large faces of which are parallel. They are kinds of prisms furrowed by parallel and longitudinal grooves.

The acid and alkali, of which nitre consists, are united together so intimately, that it may be considered as a perfect neutral salt. It is not deliquescent, but it retains strongly the water of its crystallization, by which its transparency is preserved even in a dry air, and it does not effloresce, or become mealy.

Nitre is one of the most fusible salts. It is liquefied by a heat much less than what is necessary to make it red, and remains thus in tranquil fusion without swelling. If nitre thus melted be left to cool and fix, whether it has been made red-hot or not in this fusion, it coagulates into a solid, sonorous, semitransparent mass, and is then called *mineral crystal*. This melted nitre, or mineral crystal, has, excepting the arrangement of the crystallization, all the same properties as crystallized nitre. Mr. Beaumé observes, that nitre loses by fusion little, if any, of the water of its crystallization, since the weight of the mineral crystal is nearly the same as the weight of the nitre employed.

(l) NICKEL is a semi-metal, first described by Mr. Cronstedt, in the Swedish Memoirs for the years 1751 and 1754. The properties there attributed to it are, 1. That it is of a white color, inclining to red. 2. Its texture is solid, and shining in its fractures. 3. Its specific gravity is to that of water as 8500 to 1000. 4. It is considerably fixed in the fire. 5. It is calcinable, and its calx is green. 6. This calx is not very fusible, but it nevertheless tinges glass of a transparent reddish brown, or jacinth color. 7. It dissolves in aqua fortis, aqua regia, and marine acid, but difficultly in vitriolic acid. All these solutions have a deep-green color. The vitriol formed of it is also of the same color; and the colcothar of this vitriol, and also the precipitates from the solutions, are rendered by calcination of a light green color. 8. These precipitates are soluble by spirit of sal ammoniac, and the solution has a blue color. But no copper can be produced by a reduction of the precipitates. 9. It strongly attracts sulphur. 10. It unites with all metallic substances, excepting silver, quicksilver, and zinc. Its attraction to regulus of cobalt is the strongest, next to which is that to iron, and then to arsenic. 11. It retains its phlogiston a long time in the fire, and its calx is reducible by a very small quantity of inflammable matter. It requires, however, a strong red heat before it can be fused, and melts a little sooner, or as soon as, gold or copper. Nickel is contained in the reddish-yellow mineral, called *Kupfernickel*, which, besides nickel, contains also iron, regulus of cobalt, arsenic, and sulphur.

Hence the liquefaction of the nitre, even at first, ought not to be attributed to the water of its crystallization, as is the case with Glauber's salt and many other salts, but is a true fusion from the beginning; and this fusibility of nitre is caused by the water which enters into its composition as a salt, and not merely as a crystallized salt. Accordingly, mineral crystal is as fusible as nitre itself. The fusibility of nitre may also probably depend considerably on the inflammable principle which enters its composition, and particularly the composition of its acid. *See* ACID (NITROUS).

When nitre is kept in fusion with a moderate heat, while at the same time it does not touch any inflammable matter, nor even flame, it remains in that state without suffering any very sensible alteration. But if it be kept in a strong fire, it becomes more and more alkalised, because then the flame or burnt phlogiston penetrates it, even through the crucible, sufficiently to destroy the acid of the salt. *See* ACID (NITROUS), *and* DETONATION *of* NITRE.

From this property of being alkalised by a strong heat alone, it assists the fusion and vitrification of flints and sands as pure alkalis do. A considerable part, nevertheless, of the nitrous acid may possibly remain in the vitrified substances, or may even contribute to the fusion. *See* VITRIFICATION.

All these substances, which contain phlogiston fixed in a certain degree, and which are nevertheless combustible, being made red-hot and applied to nitre, accelerate greatly the alkalisation of this salt, and render it compleat, if these substances be in sufficient quantity: and reciprocally, nitre accelerates much and compleats the calcination or combustion of these substances, because its acid assists the burning of their phlogiston, and burns itself along with this inflammable principle.

This alkalisation is made with or without any sensible detonation, according to the state, the quantity, and the greater or less intimacy of the mixture of the inflammable matters. And the nitre thus decomposed or alkalised is frequently called *nitre fixed* by such or such substance; for instance, *nitre fixed by tartar*, *nitre fixed by coals*, when it is alkalised by tartar or by coals. This name of *fixed nitre* is improper: for when the operation is finished, the residuum contains nothing nitrous, but only the alkali of nitre, with the ashes or earth of the inflammable matter employed for this alkalisation.

The phenomena which nitre exhibits, when it is decomposed by means of phlogiston, are numerous and interesting. The detail and explanation of them may be found under the article DETONATION *of* NITRE.

Nitre is capable of being decomposed by several other substances. These are, pure vitriolic acid; vitriolic acid engaged with an earthy or metallic base; sedative salt; arsenic; and phosphoric acid. But none of these substances acts upon nitre in the same manner as phlogiston does. They do not, like phlogiston, destroy its acid, but only disengage and separate it from its alkali. Hence it follows, 1, That after the decomposition of nitre by means of these saline substances, its alkali does not remain alone, but a combination of this alkali with the substance employed for the decomposition. 2. If we make the operation in vessels proper for distillation, the nitrous acid which has been separated during the operation from its alkali may be obtained. For the detail of these operations see the words, SPIRIT *of* NITRE, SALT (NEUTRAL ARSENICAL), SALT (SEDATIVE), *and* PHOSPHORUS.

Nature

Nature furniſhes us with a very ſmall quantity of nitre ready formed, in comparison of the quantities which are employed. Nitre is found naturally cryſtalliſed in India, and as it is ſwept from earths or ſtones with brooms, it is called the *ſweepings of nitre* or *of ſaltpetre*. A nitre may be obtained from ſeveral plants. Theſe are the two kinds of natural nitre. All other nitre is only begun by nature, and is found in the walls of old buildings. Art is required to compleat it, to extract it, and to purify it, as we ſhall proceed to explain, after having made ſome reflexions on the generation of this ſalt.

As neither nitre nor nitrous acid, engaged in any baſe whatever, is any where found collected from time immemorial in great quantities, as the vitriolic and marine acids are, but is only found produced from time to time in places where not an atom of this ſalt exiſted; it evidently appears to be habitually produced by the concurrence of circumſtances favorable to its formation.

Some chemiſts and naturaliſts believe, that becauſe nitre is commonly obtained from ſubſtances long expoſed to air, that nitrous acid exiſted ready formed, like the other two mineral acids, and that it is ſucceſſively depoſited in matters proper for its reception. But this opinion is quite rejected, particularly by chemiſts, ſince they have been aſſured from experience, that by a long expoſure of the moſt proper ſubſtances for the reception and retention of nitrous acid, as fixed alkali, to the air, no nitre is ever obtained. Cloths ſoaked in fixed alkali, and expoſed to air by hanging freely, are indeed at length filled with cryſtals of a neutral ſalt; but this is vitriolated tartar, and not nitre.

On the other ſide, we are certain that nitre or nitrous acid, engaged in any baſe, is never found but in places capable of being impregnated with vegetable or animal juices. Hence, it is never found in any place inacceſſible to theſe matters, as in very great heights or deeps.

Mr. Lemery the younger conſidering theſe things, and that nitrous ſalts or perfect nitre are obtained by analyſing many vegetable and animal matters, has concluded from thence, that this ſalt exiſts naturally ready formed in the individuals of theſe two kingdoms, which are, according to him, the only ſource of it. In the Memoirs he has given upon this ſubject, he explains how nitre, or rather nitrous acid, which is either at firſt not perceptible, or in ſmall quantity, in animals and vegetables, may be afterwards unfolded by the action of the air, and by the fermentation excited in theſe compound bodies as ſoon as their life ceaſes.

But this opinion, although ſpecious, is liable to great difficulties; for vegetables and animals are not permanent beings, but are continually produced and deſtroyed. The peculiar ſubſtances then, of which they are compoſed, conſiſt of principles extracted from the air and the earth. We may therefore object to Mr. Lemery, that the nitre found in animals and vegetables is extraneous to them, and proceeds originally from the air and the earth.

This objection is ſupported by a well known fact, namely, that the moſt nitrous plants contain very unequal quantities of it, according to the quantity of the nitre which is contained in the ſoil or earth in which they grow. Beſides, vegetable and animal ſubſtances may be putrified without affording a larger quantity of nitre, unleſs it has been expoſed to the air and mixed with earthy and ſtoney matters. Vegetable and animal matters contain the nitre or nitrous acid ready formed, only *accidentally*; they do not even always contain

tain all the materials necessary for its production: and all that we can infer is, that the concurrence of animal and vegetable matters is necessary for this production of nitre.

The third opinion concerning the origin of nitre is that of Stahl. This chemist, who thought, with Beccher, that the vitriolic is the only original acid, and that from this all other acids are produced, believed that the nitrous acid is only the vitriolic acid metamorphosed by the union it contracts with some other principle. This principle, according to him, is phlogiston: and putrefaction is the method employed by nature to combine this acid with the inflammable matter of putrifying substances, in the convenient proportion and manner for giving to it the specific character of nitrous acid.

This is the most probable opinion of all. For without considering the analogies which are observable betwixt the nitrous and the volatile sulphureous acids, most of the circumstances attending the origin of nitre seem to be further proofs of it.

First, the atmosphere appears to contain the vitriolic acid, or some matter in which it exists, and from which it is deposited in proper bases.

Secondly, nitre is never found but in earths or stones which have been impregnated with vegetable or animal juices, and these juices must have remained a sufficiently long time to have sustained the whole putrefactive process.

Thirdly, Messrs. Mariote and Lemery have exposed to pure air, during a long time, earths and stones very fertile in nitre, after having deprived them of all their contents, and no nitre was formed in them, because they had not again imbibed any vegetable or animal juices.

Lastly, the Academy of Sciences at Berlin, having proposed some years ago, for the subject of their annual prize, to determine the origin and principles of nitre, Dr. Pietchs, who obtained the prize, says in his Dissertation, that having soaked with urine and vitriolic acid a calcareous stone, and having afterwards exposed it to the air during some time, he found it afterwards full of nitre. This experiment is favorable to Stahl's opinion, which Mr. Pietchs adopts in his Memoir.

One part indeed of the observations which we have related agrees also with Mr. Lemery's opinion. But whether nitre be produced in vegetables and animals during their life, as Lemery believes; or whether a part of the principles of these substances combines afterwards with the vitriolic acid diffused in the air, or pre-existing in earths and stones, as Stahl says; this may certainly be inferred, that nitre does not exist ready formed, and in great quantities in nature, as the vitriolic and marine acids are, but that it is generated and produced from time to time by the concurrence of circumstances favorable to its formation.

We may observe upon the subject of the principles and production of the nitrous acid, that as we have shewn that putrefactive matters are requisite to its formation, and as vegetable and animal substances are only susceptible of putrefaction, this acid therefore belongs equally to the three kingdoms of nature.

Nitrous acid is not commonly found disengaged: neither is it generally united with any one particular basis, as marine acid is; but it is no sooner generated, than it combines with any matters which it can dissolve, and which are within

its

its reach. Accordingly, it is ſometimes united with a fixed alkali, and conſequently forms ordinary nitre; ſuch are what are called the ſweepings of nitre and the nitre of plants; but moſt frequently it is combined with abſorbent earths, becauſe it generally meets theſe in places where it is formed moſt copiouſly: it is, therefore, moſt generally found in the form of nitre with an earthy baſis.

The moſt favorable places for the production of nitre are the habitations of men and animals, and particularly ſuch as are low and moiſt, as cellars, kitchens, ſtables, houſes of office, and others of that kind, which are apt to to be impregnated with vegetable and animal matters, and alſo to have an habitual moiſture, which is favorable to putrefaction; and, laſtly, which are ſheltered from rain, which might otherwiſe diſſolve and carry off the nitre as ſoon as it is formed.

Theſe buildings are true nitre-beds. When they are old, their rubbiſh and plaſter are full of nitre: but this nitre is only a nitre with an earthy baſis, which is not ſuſceptible of cryſtallization or detonation, which are the two eſſential qualities in nitre for the principal uſes to which it is applicable, and which it cannot poſſeſs but by being joined to a baſis of fixed alkali. Beſides, the nitre of rubbiſh is mixed with much common ſalt, which comes alſo from the vegetable and animal matters, and from ſome heterogeneous ſubſtances, which alter its purity. The chief intention, therefore, of the operation upon rubbiſh, to obtain a perfect nitre, is to furniſh this ſalt with a baſis of fixed alkali, and to diſengage it from the heterogeneous matters which alter its purity. Theſe views are accompliſhed in the following manner.

The rubbiſh containing nitre is to be broken to ſmall pieces, and mixed with nearly an equal quantity of wood-aſhes. This mixture is to be put into caſks ranged along each other, placed vertically on one of their ends, and ſupported at the height of two feet above the ground. At the bottom of each caſk is a hole, filled with ſtraw. Water is to be poured into the firſt caſk; and this water, when impregnated with all the ſaline matter in the mixture, flows into a bucket placed under the caſk for its reception. This ſame water is poured ſucceſſively into the other caſks, and thus becomes impregnated with more and more ſaline matter. The makers of ſalt-petre obſerve always to paſs the ſtrongeſt lixiviums through caſks filled with new matter; and before they throw away the matter of a caſk when almoſt exhauſted, they paſs through it the firſt water yet unimpregnated. By theſe operations, which are well contrived, they obtain a lixivium as much impregnated as it can be, and they at length entirely exhauſt the rubbiſh of all the nitre it contained.

The lixivium of nitre thus prepared is carried to great copper cauldrons, in which it is boiled and evaporated, till it is ſufficiently ſtrong for the cryſtallization of the ſalts. As the two cryſtallizable ſalts contained in this lixivium are nitre and common ſalt, and as the latter of theſe ſalts is cryſtallizable by evaporation only, and the ſecond by cold only; the common ſalt cryſtallizes firſt during the evaporation, and forms ſmall cubical cryſtals which ſubſide to the bottom of the cauldron. The ſalt-petre-makers call it the *grain*. They take it out with large ladles, and put it in a baſket hung over the cauldron to drain. This evaporation is continued, and the grain is to be taken away as faſt as it is formed, till the liquor be ſo much evaporated, that, when it is cold, much nitre will

will be cryſtallized in it; and in order to diſcover when it is ſufficiently evaporated for that purpoſe, a ſmall quantity of it is to be taken out from time to time. When they perceive, upon cooling the liquor, that a ſufficient quantity of nitre is formed in it, they remove the liquor from the cauldron into large copper baſons, which they carry to a place deſigned for the cryſtallization.

As this liquor contains much nitre, and as it is quickly cooled, the greateſt part of the ſalt is coagulated at the bottom of the baſons in unſhapely maſſes, compoſed of many ſmall needle-like cryſtals of nitre, and ſometimes of large regular cryſtals upon their ſurfaces. Theſe are called *ſticks of nitre*.

In the baſons remains a large quantity of liquor, the nitre contained in which cannot be cryſtallized but by a ſecond evaporation, which is therefore performed in the ſame manner as at firſt, and more nitre is obtained. This operation is repeated till no more nitre can be formed by cooling the evaporated liquor, which then becomes very red and acrid, and is called the *mother-water of nitre*.

This mother-water is compoſed almoſt entirely of nitre and common ſalt with earthy baſes, which certainly proceed from too ſmall a quantity of aſhes having been mixed with the lixivium of the nitrous rubbiſh. This mother-water may therefore be avoided, by mixing a ſufficient quantity of aſhes with the nitrous rubbiſh, to decompoſe all the ſalts with earthy baſes which it contains; and thus, after the ſeveral evaporations and cryſtallizations, nothing would remain but a ſmall quantity of red liquor impregnated with unctuous matter.

When only the uſual quantity of aſhes is employed, the baſis of the earthy ſalts contained in the mother of nitre may be precipitated by adding an alkaline lixivium. This precipitate is white, and is called the *magneſia of nitre*; and, at the ſame time, the nitre with earthy baſis in the mother-water, being changed into a nitre with baſis of fixed alkali, is eaſily obtainable by cryſtallization: but the ſalt-petre-makers do not employ any of theſe methods with their mother-water, which they throw upon the nitrous rubbiſh after it has been exhauſted of its ſalt by lixiviation. Some time afterwards, they lixiviate this rubbiſh in the ſame manner as they did at firſt, that is, with the addition of aſhes, and obtain from it more nitre. We may eaſily perceive that this operation is preciſely upon the ſame principles as one of thoſe we have propoſed. *See the words* WATER (MOTHER), NITRE *with* EARTHY BASIS, SALT (COMMON) *with* EARTHY BASIS.

The nitre obtained by theſe cryſtallizations is red, and ſoiled by the liquor in which it was diſſolved, which has alſo that color. Further, although common ſalt does not cryſtallize by cold alone, yet a certain quantity of it always cryſtallizes along with the nitre; both becauſe the evaporation continues while the liquor cools, and becauſe the nitre, during its cryſtallization, always takes with it a portion of common ſalt.

This nitre, which the manufacturers call *nitre of the firſt boiling*, is therefore impure, and mixed with common ſalt, and with ſalts with earthy baſes, by which it is rendered unfit for many of the uſes to which nitre is applied, as we ſhall afterwards ſee. It is purified by diſſolving it in pure water, and by proceeding to a ſecond cryſtallization by cold; and as in this ſecond cryſtallization, the proportion of nitre to common ſalt, and to ſalts with earthy baſes, is infinitely greater than at firſt, ſo that when the liquor is at the point of the cryſtallization of the nitre, it is very far from being ſo much evaporated that the common

mon ſalt can cryſtallize at that time; and therefore the nitre obtained in this ſecond operation is infinitely purer than that of the former. It is alſo white, and is called by the manufacturers *nitre of the ſecond boiling*. This is the nitre employed by diſtillers of aqua-fortis, for the ordinary aqua-fortis.

But this nitre is not yet ſufficiently pure for the preparation of good gunpowder; and it muſt therefore be purified by a third boiling or cryſtallization. This is the pureſt nitre that is ſold, or that is kept in arſenals. It is very beautiful and white: but it is not yet ſufficiently pure for certain delicate operations in chemiſtry, and muſt therefore undergo a fourth purification. For the underſtanding of the theory of the operations for the extraction and purification of nitre, *ſee the article* CRYSTALLIZATION *of* SALTS.

All nitrous earths and ſtones which are found, contain alſo a conſiderable quantity of common ſalt. The late Mr. Petit, who has given, in the Memoirs of the Academy of Sciences, a good deſcription of the manufactory of ſalt-petre, ſays, that the quantity of common ſalt contained in the materials is nearly a fourth part of the quantity of nitre. It is even probably more, if we comprehend the common ſalt with earthy baſis contained in the mother-water of nitre.

This common ſalt is depoſited in the nitrous earths and ſtones by the vegetable and animal juices which are neceſſary to the generation of nitre, all which contain more or leſs common ſalt. The exiſtence of this common ſalt in all nitrous ſubſtances has induced ſome chemiſts to believe that the marine acid was converted into the nitrous. I have heard that a certain perſon had the ſecret of transforming common ſalt into nitre, and that he had propoſed to furniſh nitre at a cheap rate. A more particular examination of this matter deſerves to be made by chemiſts.

No uſe is made in France of the common ſalt in the manufacturing of ſalt-petre. The farmers-general oblige the manufacturers to give an exact account of it, and to throw it into the river. The purification of it would be difficult; becauſe, during the making of the ſalt-petre, a febrifugal ſalt of Sylvius is formed, by the union of the vegetable alkali of the aſhes, with the acid of the marine ſalt with earthy baſis; and becauſe the ſalt of Sylvius has all the properties of common ſalt, only that its taſte is very diſagreeable.

The uſe of nitre is very extenſive in medicine, and in the arts, and in chemiſtry. Perſons who know little of chemiſtry muſt be ſurprized that this ſalt, ſo inflammable, ſhould be employed in medicine as a powerful diuretic, ſedative, and cooler; which virtues it certainly poſſeſſes. It is daily preſcribed by the moſt ſkillful phyſicians, from ten or twelve grains to half a dram, in ſome proper drink. It might be given without danger in a much more conſiderable quantity; for this ſalt, which is perfectly neutral, is very mild; but it has been obſerved to produce its intended effects better when it is given in the above-mentioned quantity only. *(m)*

(*m*) Some curious experiments concerning the effects of nitre taken internally are related in *Mr. Alexander's Experimental Eſſays.* From theſe it appears, that nitre has a power of almoſt inſtantly retarding the velocity of the circulation of the blood, and of ſurpriſingly diminiſhing the number of arterial pulſations; and that its effects are much more powerful, when newly diſſolved in water, than when it had remained diſſolved during ſome hours. As this difference muſt have proceeded from the cold, which is produced

Besides the nitrous acid obtained from nitre, which is one of the most powerful agents in chemistry, nitre itself is also used in many chemical operations. Its properties of detonating with bodies containing phlogiston, of accelerating their calcination, and particularly the calcination of the imperfect metals, render it useful for the purification of gold and silver when they are allayed with other metals. As nitre is quickly and easily alkalised, it enters into the composition of reducing fluxes, or of simple fluxes, to assist fusion and vitrification. Lastly, by its detonation it may be employed to discover the presence of the inflammable principle in substances.

But the most considerable use and consumption of nitre is in the preparation of gun-powder, of which this salt makes a great part; and for this purpose it must be very pure. *See* POWDER (GUN), *and* POWDER (FULMINATING).

CCCCLXXIII. NITRE (ALKALISED.) This is the fixed alkali which remains after the nitrous acid has been destroyed by its detonation with any inflammable matter. This alkali is generally called *fixed nitre*. *See* NITRE (FIXED).

CCCCLXXIV. NITRE (AMMONIACAL). This is a neutral salt resulting from the combination of the nitrous acid, to the point of saturation, with volatile alkali. *See* AMMONIACAL (NITROUS) SALT.

CCCCLXXV. NITRE (CALCAREOUS), or NITRE *with* EARTHY BASIS. Calcareous nitre is a neutral salt compounded of the nitrous acid combined to saturation with a calcareous earth. It is generally called *nitre with an earthy basis*, because the salts formed by the nitrous acid with the other earths have not been attended to.

Nitrous acid dissolves with great activity all calcareous earths and stones, calcined or uncalcined. It dissolves a large quantity of them, and leaves no residuum when they are pure. By this combination is formed a neutral salt very deliquescent. This salt is not susceptible of a true crystallization. It has a poignant, acrid, and bitter taste. If it be evaporated to dryness, it becomes solid, and seems to be an earthy matter, which does not detonate, or at least very weakly, with inflammable matters.

All these properties of nitre with an earthy basis proceed from the weak adhesion of its acid to the earth. This adhesion is so weak, that if the salt be distilled in a retort, an acidulous phlegm will first pass over; and when the fire is encreased, all the acid will follow, excepting a small portion which adheres more strongly, but which may be at last expelled by calcination in an open fire.

Mr. Pott, who has particularly examined the combination of nitrous acid with quicklime, says, that this acid suffered remarkable alterations by distillation from quicklime, and by repeated cohobations. By these experiments he obtained a nitrous salt more sensibly susceptible of crystallization and detonation than ordinary nitre with earthy basis; which is very remarkable, and may induce us to suspect that a part of the nitrous acid, and of its inflammable principle, might combine with the quicklime, so as to give it the character of

duced by nitre during its solution, probably a much greater effect would be produced by procuring that solution in the stomach. A remarkable instance is given in that book of a sudden swelling over the whole body of a woman, and other dangerous symptoms, which were occasioned by her swallowing a solution of nitre in water, by mistake, instead of Glauber's salt.

a fixed

a fixed alkali; or that the nitrous acid, deprived by the quicklime of part of its phlogiston, might be rendered more capable of contracting a strong union with the quicklime. From what Mr. Pott has said in his Dissertation, the nitrous acid seems, by treatment with quicklime, to be rendered susceptible of an entire decomposition. *See his Dissertation in the French edition of his works, by Mr.* MACHY, *tom.* III. *p.* 178.

A great quantity of nitre with earthy basis is found ready formed in nitrous earths and stones. Nitre is most frequently produced in that form. This nitre may be decomposed by a fixed alkali, which unites with its acid, and precipitates the earth, in the process for making salt-petre. The mother-waters obtained in these operations contain still a large quantity of this nitre with earthy basis. *See the word* NITRE *in the preceding article.*

CCCCLXXVI. NITRE (CUBIC *or* QUADRANGULAR). When nitrous acid is saturated with mineral alkali, a neutral salt is formed, susceptible of crystallization and of detonation, and consequently is a kind of nitre. This salt has all the essential properties of nitre with basis of fixed vegetable alkali; but the marine alkali, which is its basis, changes the form of its crystals, which are not channelled prisms, like those of ordinary nitre, but are cubes, or sometimes parallelipipedons, with rhomboidal faces. From these forms the salt has been called *quadrangular nitre.*

We may make quadrangular nitre by combining directly the nitrous acid to the point of saturation with the crystals of soda, or by precipitating with this alkali the solutions of earths and metals made by nitrous acid, or by precipitating with common salt the metallic solutions in nitrous acid, which are susceptible of this precipitation; or, lastly, by decomposing common salt by pure nitrous acid in the operation for making the distilled aqua regia. In all these cases the nitrous acid is evidently combined with marine alkali, and forms cubic nitre. This salt is not used in medicine, chemistry, or the arts, as it is rather inferior than preferable to ordinary nitre.

CCCCLXXVII. NITRE FIXED *by* ARSENIC. This preparation is the alkali of nitre, the acid of which has been expelled in an open fire by means of arsenic, of which, therefore, some portion is retained by the alkali. To make this preparation, some nitre is to be put into a crucible, which is to be placed in a furnace. When the nitre is red, a small spoonfull of white arsenic powdered is to be projected upon it, which causes a great effervescence, and afterwards vapors to ascend; so that these phenomena are similar to those which happen when nitre is detonated. They are, however, different. In the detonation of nitre, the acid is burnt and destroyed; but in this operation the acid is only disengaged from its basis by means of the arsenic which has that property. The ebullition above-mentioned is caused by the powerful action of arsenic upon nitre. The fumes which rise copiously in this operation are a mixture of those of very concentrated nitrous acid with a part of the arsenic which is sublimed by the heat.

Arsenic is thus projected at different times into the crucible, till no more effervescence is perceived, and then the operation is finished. The fumes which rise in this experiment must be very noxious, and therefore it ought always to be done under a chimney which draws well.

As arsenic cannot disengage the nitrous acid but in proportion as it combines with the basis of the nitre, we might expect to find in the crucible, after the operation, the alkali of the nitre perfectly saturated with arsenic. Nevertheless, the remaining matter is very alkaline, very far from the point of saturation, and retains but a little arsenic. The cause of this is, that the contact of the air and the vapor of the coals make most of the arsenic fly off as fast as it combines with the alkali; for when the evaporation is made in close vessels, the alkali of the nitre is neutralised, and entirely saturated with arsenic. *See* ARSENIC, *and* SALT (NEUTRAL ARSENICAL).

Nitre fixed by arsenic cannot be employed but as an alkali which contains a certain quantity of arsenic, and mixed with a small portion of nitre which may escape the action of the arsenic towards the end of the operation. This alkali may be employed as a flux, as it powerfully assists vitrification, as Mr. Pott has done in his experiments mentioned in the Lithogeognosia.

CCCCLXXVIII. NITRE FIXED *by* COALS. To make nitre fixed or alkalised by coals, the proper quantity of nitre is to be put into a crucible, which ought to be so large that the nitre shall take up but a small space in it. This crucible is to be placed in a well kindled fire; and when the nitre is melted and red-hot, a small spoonfull (about a dram or half a dram) of charcoal grossly powdered is to be projected upon it. Instantly a vivid inflammation happens, which continues till all the charcoal is entirely consumed. When this inflammation or detonation ceases, another quantity of charcoal like the former is projected upon it, and is left to be consumed; and thus charcoal is continually to be projected till no more detonation is caused by it.

Then the matter contained in the crucible, which at first is very fluid, becomes afterwards thick and almost solid, because it is then fixed alkali, which is much less fusible than nitre. The fire must be encreased sufficiently to make this alkali melt. During this fusion, some small detonations happen from time to time, which are occasioned by a portion of nitre which the large quantity of alkali, and the want of fluidity towards the end of the operation, had preserved from the contact of the coals. When the matter is in good fusion, and no detonation happens upon projecting small bits of coals, we may then know that the nitre is alkalised, and that the operation is finished. We ought to remark upon this subject, that when the smallest possible quantity of nitre undecomposed is intended to be contained, more coal must be added than seems to be necessary for alkalising the quantity of nitre. In this case the alkali is generally phlogisticated, unless it be afterwards calcined a very long time in an open fire.

If, on the contrary, it is intended to be as much dephlogisticated as possible, and incapable of giving or retaining any extraneous taste or smell; and if its perfect purity from undecomposed nitre be not required; then in the preparation less charcoal ought to be used than is necessary for the detonation of the whole quantity of nitre. This remark is also applicable to nitre alkalised by tartar and by all other inflammable matters. *See* ALKALI (FIXED VEGETABLE); *and* DETONATION *of* NITRE.

CCCCLXXIX. NITRE FIXED *by* METALS. All the metallic substances which are susceptible of decomposition being treated in the fire with nitre, alkalise it, and make it detonate more or less sensibly. The most inflammable of these substances, as zinc and iron, make with this salt so luminous and so brilliant a detonation, that they are advantageously employed for that purpose in fire-works. Other combustible matters are less effectual, but their inflammation with nitre is sufficiently strong to produce all the essential effects of the detonation of nitre; so that after this inflammation, the acid of the salt is destroyed and burnt with the phlogiston of these metals, and its alkali only remains mixed with the earth of the calcined metals. We may then say, that nitre is fixed by metals, as well as we say that it is fixed by coals or by tartar.

After the detonation of nitre with metals, its alkali may be easily obtained alone, and separated from the metallic earths, by lixiviating with water the remainder. By filtrating and evaporating this water, this kind of fixed nitre may be obtained in a dry state. It is essentially the same as nitre alkalised by any other inflammable matter, only that it is much more acrid and caustic, and resembles those alkalis which have been treated with quicklime.

In some known operations of chemistry we may observe this causticity which the alkali of nitre acquires after detonation with metallic matters. Such are the operations for diaphoretic antimony, and for the tincture of metals, or *lilly of Paracelsus*, in which the alkalised nitre is rendered exceedingly caustic by the metallic calxes. As, on the other side, volatile alkali treated with these metallic earths becomes always *fluor*, in the same manner as when treated with quicklime, we may conclude that metallic calxes act in general upon alkalis as quicklime does. *See the articles of the several metals, and of* ALKALI (FIXED), *and* DETONATION *of* NITRE.

CCCCLXXX. NITRE FIXED *by* TARTAR. This alkali is made by mixing together equal parts of nitre and tartar, which ought to be only grossly powdered. This mixture is to be put into an open vessel of unvarnished earthen-ware, or of iron. It is to be placed under a chimney, and it is to be kindled with a lighted coal. It kindles around the charcoal, and deflagrates at first weakly: but as the matter first inflamed kindles the rest, the detonation encreases, a thick fume rises, and the whole mixture is inflamed. The red and burning matter melts, boils, and flows over the vessel if this be not sufficiently large: then the detonation gradually diminishes, and at last ceases. The residuum consists of the alkalis of nitre and of tartar mixed together.

This alkali, as well as the nitre fixed by coals, are each of them very pure and good. They are, however, subject to contain a considerable quantity of nitre undecomposed, and of inflammable matter not burnt, particularly when a small quantity only is prepared at once: but it may be compleatly alkalised by a proper calcination, and by treating them like other fixed alkalis. *See* ALKALI (FIXED VEGETABLE).

Nitre fixed by tartar is also called *white flux*, because the most frequent use of this alkali is to facilitate the fusion of ores and metallic matters in essays and

similar operations, for which purposes it need not be perfectly pure. *See* FLUX (WHITE), *and* DETONATION *of* NITRE.

CCCCLXXXI. NITRES (METALLIC), *or* NITRES *with* METALLIC BASES. Thus may be named all neutral salts composed of the nitrous acid united with a metallic substance; and the several kinds of these nitres may be distinguished by saying, nitre of silver, nitre of lead, of mercury, &c. *See* SALTS.

The nitrous acid acts in general powerfully upon all metallic substances, but with remarkable differences, depending on the peculiar natures of the metals.

Some metals, as gold and platina, cannot be dissolved in their state of aggregation by nitrous acid alone, and require the concurrence of marine acid. Others, as tin and regulus of antimony, are attacked so powerfully, and are so well dephlogisticated by nitrous acid, that, as soon as they are dissolved, they are reduced into a white calx, which separates from the acid, and cannot remain united, because they want phlogiston. The marine acid combined with nitrous acid moderates much the action of the latter acid on these metals, prevents their calcination, preserves a part of their phlogiston, and thus is an intermediate substance by which they remain united with the nitrous acid.

Other metals, such as copper and iron, are easily soluble by nitrous acid alone, and remain united when the acid is in much larger quantity than is necessary to dissolve the metal: but when the acid is saturated, a part of these metals always precipitates in state of calx, and the part which remains united with the acid forms an imperfect neutral salt, very deliquescent, and not, or very little crystallizable.

Lastly, the other metals, particularly those called *white* or *lunar*, such as silver, lead, mercury, bismuth, and even regulus of arsenic, are very soluble in nitrous acid, which they saturate, from which they do not precipitate without addition, but form with it compleat neutral salts susceptible of crystallization.

Nitrous acid adheres so strongly to these metals, that the metallic salts formed by them are susceptible of detonation, but not sufficiently to resist the action of fire, which expels it without the help of any intermediate substance.

The nitre of silver is known by the name of lunar crystals. *See* CRYSTALS (LUNAR). Mercurial nitre is also frequently called *crystals of mercury*. This salt resembles much the nitre of silver by its principal properties. *See* MERCURY. The nitre of lead has this peculiarity, that by exposure to fire without addition of inflammable matter, it decrepitates strongly, and even inflames and detonates. This phenomenon must be attributed to the phlogiston of the lead which is the basis of this salt. Much danger therefore attends the exposure of nitre of lead to fire in close vessels. Probably the nitre of bismuth, and that of regulus of arsenic, would exhibit the same phenomenon, as the phlogiston of these two semimetals is as inflammable as that of lead.

CCCCLXXXII.

CCCCLXXXII. NUTMEG. (*n*)

(*n*) NUTMEGS. This fruit contains two kinds of oils, namely, a groſs ſebaceous oil, and a volatile eſſential fluid oil; in which laſt the peculiar taſte and ſmell of nutmegs reſide. The eſſential oil alſo appears to be of two kinds; one of which is ſo light, as to ſwim upon water, and to riſe in diſtillation with ſpirit of wine; and the other is ſo groſs and ponderous, that it ſinks in water, and is with difficulty capable of being diſtilled with water, and not at all with ſpirit of wine. Sixteen ounces of nutmegs yielded, by diſtillation, half an ounce of eſſential oil, and afterwards four or five ounces of the groſs ſebaceous oil were found floating on the ſurface of the water in the ſtill. Rectified ſpirit of wine diſſolves all the eſſential oil, and a part of the expreſſible oil. From four ounces of nutmegs nine drams of a concrete oil were expreſſed. This oil contains a conſiderable portion of the eſſential oil. It is brought from India, in form of cakes, and is called *oil of mace*, the mace being one of the exterior coverings of the nutmeg, and containing ſimilar oils. *Neuman.*

CCCCLXXXIII.

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CCCCLXXXIII. **O**CHRE. (*o*).
CCCCLXXXIV. OCULUS MUNDI. (*p*).
CCCCLXXXV. OFFA ALBA. (*q*).
CCCCLXXXVI. OIL. Oil may in general be defined a compound body, little, if at all, soluble in water, which is capable of burning with a flame accompanied with ſmoke and ſoot, and of leaving a reſiduum of coal after its diſtillation.

All oils are compoſed of phlogiſton, acid, water, and earth; for all theſe principles are diſcovered in the decompoſition of any oil, as we ſhall ſoon ſee.

(*o*) OCHRE. Ochres are ferruginous earths, or calxes of various colors, red, yellow, brown. They ſeem to have been depoſited from ferruginous or vitriolic waters, nearly in the ſame manner as a reddiſh or yellowiſh powder is precipitated from ſolutions of iron in vitriolic acid merely by expoſure to air. By reduction with charcoal or other inflammable matter, a conſiderable quantity of iron may be extracted from theſe earths. Wallerius ſays, that the iron thus obtained from ochres is of the kind called *red-ſhort*, that is, brittle when hot. Ochres are uſed as pigments. By calcination, they all acquire a red color. *See* ORES *of* IRON.

(*p*) OCULUS MUNDI is a variety of the opal. *See* OPAL. It is opake, and its color is generally yellowiſh. It has this peculiar property, that by lying ſome hours in water, it becomes tranſparent, and of a yellow amber color. Some are ſaid to acquire by this means a luminous flame color.

(*q*) OFFA ALBA, *or* OFFA HELMONTII. When rectified ſpirit of wine is added to a ſolution of mild volatile alkali in water, the ſpirit having a ſtronger diſpoſition than the alkali to unite with the water, and having no diſpoſition to unite with the alkali, precipitates the alkali from the water. The alkali thus precipitated, being mild, or combined with fixable air, acquires a ſolid or concrete ſtate, and is not different from the common mild concrete volatile alkali. It is called the *offa alba*, or *offa Helmontii*. No ſuch precipitation is effected by adding rectified ſpirit of wine to the cauſtic volatile alkaline ſpirit made with quicklime, becauſe the diſpoſition which cauſtic volatile alkali has to unite with water is ſo much ſtronger than that of mild volatile alkali, that the former cannot be ever obtained in a concrete ſtate. *See* ALKALI (VOLATILE).

But perhaps the water and earth which are in oils are in them combined together, and exist in the state of an acid.

From what we have said concerning the nature of oil, this substance appears to consist of several principles (*r*). It is also one of the proximate principles of all vegetables and animals. The oil in these substances even constitutes the essential distinction betwixt them and those of the mineral kingdom, for in no mineral can the smallest particle of oil be shewn. *See* KINGDOMS.

All the oil obtained from vegetable and animal substances has a certain number of general properties which form its character as oil; but is also much diversified by many peculiar properties, according to the particular kinds of vegetable and animal matters from which it is extracted. Hence, the several kinds of oils are distinguishable from each other. In the present article we shall only mention the most general properties of oil.

All oils in general are volatile, that is, they may by a certain heat be raised into vapors. The heat necessary to evaporate the least volatile oils is not even very considerable. It is much less than a red heat; accordingly oil may be considered as a volatile body.

All oils which are exposed to a heat capable of evaporating them, are easily inflammable, in open air, by contact of any inflamed matter, and burn with a white, luminous flame, accompanied with smoke. Oils, like all other combustible bodies, are entirely decomposed by their inflammation. This inflammability of oil shews that phlogiston is one of its principles.

The inflammable property of oil has misled the ancient chemists down to the time of Becher and Stahl. They gave the name of *oil* to the inflammable principle of metals, of sulphur, and of charcoal, as well as to what is properly called oil. But the inflammable principle which enters into the composition of these bodies is only one of the constituent parts of oil; and oil cannot transfer this principle to any other body without being previously decomposed, and ceasing to be oil. *See* PHLOGISTON.

If any oil be distilled without an intermediate substance, at first a little acid phlegm arises, and afterwards the oil itself; and when a greater degree of heat than that of boiling water has been necessary to raise it, it always acquires an empyreumatic quality, so much stronger as the heat requisite to be employed was greater. This oil is always accompanied with an acid, which becomes more and more strong as the distillation advances. In the retort a small quantity of fixed and residuous coal remains. This coal, and also the soot of oil, are very difficultly combustible; but at length their whole inflammable principle may be burnt: then nothing remains but ashes, which, when well washed from any vestige of fixed alkali which they may contain, are a pure earth.

If the oil in the receiver be examined, we shall find that it is less in quantity than the oil originally employed; from which we may know that a quantity of oil has been decomposed by the operation. The water, acid, and earth evidently proceed from the decomposed portion of oil. Hence all oil contains

(*r*) Besides the principles or constituent parts of oil, mentioned in the text, we may add, that oils when decomposed by heat, or by mineral acids, emit a very large quantity of elastic vapor, or a kind of fixable air.

the principles mentioned in the definition. This is further ascertained by redistilling the same oil, by which another portion of it is decomposed, and the same principles are obtained. By repeating the operation a number of times, the whole oil may thus be decomposed into water, acid, earth. The phlogiston of the decomposed oil is dissipated in insensible vapors, which cannot be confined and collected, excepting that portion of it which remains fixed in the residuous coal.

An important remark may be made on these repeated distillations of oils, which is, that the undecomposed portion of oil which passes over into the receiver, becomes by each distillation more and more thin and volatile. But as oils chiefly differ from each other in greater or less fluidity and volatility, by repeated distillations, therefore, these differences are lessened, and all oils are approximated to a common state.

These experiments have not been prosecuted so far, as to enable us to determine the possibility of reducing all oils to one and the same state; but every thing inclines us to believe that possibility: and in this case we must conclude, that oil in its greatest purity and simplicity, and which might be called the *oily principle*, is essentially and identically the same in all vegetable and animal matters; and that the differences, although very numerous and considerable, betwixt the several kinds of oils, proceed only from the extraneous matters combined with them, by the mixture of which their essential properties are more or less altered, or disguised.

We have further another very important consideration upon this subject, to which we ought to attend, and which seems to counteract the opinion we have now explained. This is, that the greater thinness and volatility which oils have, either naturally, or by repeated distillations, the less soot they form when burnt, the less residuous coal they leave, and the stronger disposition they acquire to mingle together, or to dissolve in water; so that by continuing this attenuation of oils, they might probably be brought to the state of ether, and perhaps to that of ardent spirits, which certainly is essentially different from that of oils. Hence we learn, that by repeated distillations, oils are not only purified and rendered simpler, but are also essentially altered and changed.

All oils are also capable of alteration by the action of air, and by the concurrence of other circumstances which favor fermentation. The thinnest and most volatile part of them is dissipated; hence they become thick, and less volatile; and also the acid combined in oils thus exposed is more and more unfolded, and disengaged.

Acids have in general a power of acting upon oils. But the effects produced by their combination with them are very various, according to the nature of the acid, to its degree of concentration, and to the kind of oil.

Mineral acids, even the strongest, act in general but very weakly or not sensibly upon oils, when they are diluted in a large quantity of water; because this water with which they are more than saturated, and with which they have a strong affinity, prevents their acting efficaciously upon the water and phlogiston which are principles of the oil. But when they are concentrated sufficiently, they unite then to the principles of the oil, with a force proportionable to the degree of concentration of the acid, and to the affinity which it has with the inflammable principle, and with water.

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Concentrated vitriolic acid attacks powerfully all the principles of oil, occasions an ebullition, considerable heat, and vapors, the smell of which is that of volatile sulphureous acid mixed with empyreuma. By this mixture, the color of the oil is changed to a brown, red, or blackish, and its consistence is rendered very thick.

The action of nitrous acid upon oils is still more vivid, more quick, and remarkable than that of vitriolic acid. From this mixture a more considerable quantity of vapors rise, the effervescence is much stronger, the thickening of the oil is sooner effected, and the heat is so great with most oils, that when the nitrous acid is much concentrated, the mixture becomes red-hot, and is instantly inflamed. *See* Inflammation *of* Oils.

The action of even the most concentrated marine acid is very different from that of the vitriolic and nitrous acids upon oils; it is much weaker, and we may even say that marine acid does not form any union with oils.

The difference of the effects of these three acids upon oils evidently proceeds from the difference of their affinities with the inflammable principle: for we may observe a similar gradation in the action of these acids upon oils, and upon metallic substances.

As the several kinds of oils have their peculiar characters and properties, they also show considerable diversity in the phenomena exhibited by mixture with acids. We shall find some details on this subject under the several articles of the different kinds of oils. We shall only observe here, in general, that the vitriolic and nitrous acids are disposed to unite very intimately with all oils that are very thin, volatile, and inflammable. But these qualities make them even elude the action of the acids when much concentrated; for during the reaction, they are almost entirely, and sometimes instantly, dissipated in vapors.

The oils which are least thin and volatile, and which are disposed to thicken spontaneously by the evaporation of their most subtle parts (which property they owe to a certain quantity of resinous or gummy matter contained in them), are capable of sustaining all the action of acids, and therefore are the fittest to be inflamed by mixture with concentrated nitrous acid.

Lastly, all oils which have a certain degree of unctuosity and consistence, which are not volatile, nor disposed to thicken by evaporation, resist more the action of acids. They are not altered, nor are half decomposed, like the preceding oils, by acids. They unite with them more slowly and difficultly, and can only be thickened by the united action of the vitriolic and nitrous acids. By being united with these acids, they receive the character of an acid soap, or grease, as we shall see in the article of these oils.

The acids also are altered by combination with oils. We may say in general that acids are rendered weaker and milder by union with oils, and that this union approximates them to the character of vegetable acids, or even entirely assimilates them to these acids: so that if it be true, as we have reason to believe, that vegetables and animals are formed from minerals differently modified, the differences betwixt mineral acids, and the acids of the vegetable and animal kingdoms, must be attributed to the oily principle which the latter acids possess exclusively.

This opinion would be completely proved, if we could sufficiently simplify vegetable acids to reduce them to the quality of mineral acids, and particularly

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of the vitriolic, or to transmute perfectly a mineral acid into a vegetable acid. But these important researches have not yet been made, or imperfectly, and not so fully as they deserve.

To transmute a mineral acid into a vegetable by uniting it with the oily principle, this union probably requires to be very intimate, without, however, altering in any measure the constituent parts of the oily matter. For if we employ the vitriolic or nitrous acid so much diluted that it shall not alter the oil with which it is to be united, many obstacles will then occur to prevent its intimate combination, the removal of which obstacles, however, we must acknowledge has not been sufficiently attempted; and on the other side, if acids be employed, so concentrated that they can act easily and effectually upon oils, they will then sensibly alter and half decompose them.

If we try, for instance, to separate by distillation the vitriolic acid from an oil with which it had been combined in its concentrated state, we shall only obtain from thence a very watery and sulphureous vitriolic acid; a certain quantity of empyreumatic and sulphureous oil; a stronger vitriolic acid, but still sulphureous; a thick and bituminous empyreumatic oil; sulphur which will be sublimed to the neck of the retort; and lastly, a fixed and residuous coal, more abundant than would have proceeded from the oil, if it had been distilled alone.

In this experiment we evidently see that a part of the oil is decomposed, that the vitriolic acid is not otherwise changed than by becoming sulphureous, and that it is consequently not approximated to the nature of vegetable acids. *See* ACID SULPHUREOUS, *and* SULPHUR.

The great quantity of water mixed with the first portion of acid which rises, is certainly a part of the watery principle of the oil, since the acid employed was concentrated. This acid becomes sulphureous, and forms sulphur, from the union it contracts with a part of the phlogiston of the oil. Lastly, the residuous coal is more considerable in this distillation, because a larger quantity of earthy principle is separated from the other constituent parts of the oil, and particularly from the watery part. The small portion of the vegetable acid obtained in the distillation of oils without addition, does not appear in the present experiment, because it is disguised, or even decomposed, by the vitriolic acid.

I do not know that mixtures of concentrated nitrous acid with oils have been distilled; but probably phenomena similar to those we have mentioned would happen, with those differences only which would be occasioned by the particular properties of that acid.

Of all the experiments hitherto made on the combinations of mineral acids with inflammable matters, those concerning the mixtures of mineral acids with spirit of wine seem to promise most success for the transmutation of these acids into vegetable acids; because the mineral acids are very intimately united with the principles of the spirit of wine; because these acids are necessarily diluted with the water which is a constituent part of the spirit of wine, and which is in much larger quantity than in oils; and lastly, because the action of acids upon spirit of wine is such, that it entirely approximates that spirit to the nature of oil, altho' the inflammable principle of spirit of wine be not in an oily state, and although all vegetable acids do manifestly contain an oil. Accordingly, if we

we would proſecute this aſſimilation of mineral acids to vegetable acids, the beſt method ſeems to be by treating them with ſpirit of wine. *See* SPIRIT *of* WINE, ETHER (VITRIOLIC, *and* NITROUS).

All oils diſſolve ſulphur, and form with it a compound, called *balſam of ſulphur*. The connexion of phlogiſton with vitriolic acid ſeems to be much weakened in the ſulphur by the intervention of oil; for if balſam of ſulphur be diſtilled, the ſulphur will be totally, or in great meaſure decompoſed, ſince only the ſame principles are obtained by this diſtillation as are obtained by diſtilling the combination of the oil with vitriolic acid. *See* BALSAM *of* SULPHUR *and* SULPHUR.

Alkalis act upon all oils, and combine with them to a certain degree, but more or leſs readily, according to the nature of the oil. In general, the leſs thin and volatile any oil is, the more eaſily ſoluble is it by alkalis; and reciprocally.

From the combination of an alkali with an oil reſults a compound more or leſs thick, called *ſoap*. The oil which enters into the compoſition of ſoap becomes eaſily miſcible with water by means of the alkali, but is not perfectly diſſolved in water; for the ſolution of ſoap has always a white milky appearance; which ſhews that the oil of ſoap diſſolved in water is in a ſtate ſimilar to that of an emulſion. This proves at the ſame time that the combination of oils with alkalis is not intimate; accordingly the oil receives no alteration, or ſcarcely any from the alkalis: for it may be ſeparated by means of any acid, and then it is found to be in the ſame ſtate it was in before its entry into the ſoap. *See* SOAP.

Oils may be united with metallic ſubſtances. They attack moſt ſenſibly copper and lead. Oils diſſolve copper even without heat, and from this ſolution reſults a blueiſh-green ſhining matter. The action of oils upon this and other metals is probably by means of their acid and phlogiſton. The concurrence of the air perhaps facilitates this ſolution; perhaps even it is neceſſary.

Oils are moſt eaſily combinable with the calxes of lead, as minium, ceruſs, and litharge, probably becauſe theſe preparations are much divided, and the oils which have the greateſt diſſolving power are thoſe which are the leaſt thin and leaſt volatile. When the calxes of lead are united only in ſmall quantity with oil, they do not deſtroy its fluidity, but diminiſh it, and give to the oil the property of drying much more readily.

Theſe oils, called *drying oils*, are much uſed in painting, from their drying quality. When a large quantity of calxes of lead is combined with oil, they form with it a ſolid, opake, and tenacious body, capable of ſoftening by heat. Theſe combinations are uſeful in pharmacy, for giving a convenient conſiſtence and tenacity to many plaſters. Mr. Geoffroy has obſerved, that calxes of lead combined with oils form compounds which have ſome ſaponaceous characters; that they communicate to water nearly the ſame taſte and unctuoſity that ſoap does, and make it lather in the ſame manner; that the oil may be ſeparated from the lead by means of acids, in the ſame manner as alkaline ſoaps may be decompoſed; and that the oil thus ſeparated is entirely ſimilar to that obtained by decompoſing ſoaps. Theſe combinations of oils with metallic ſubſtances have been examined but ſuperficially by chemiſts; nevertheleſs, they

present very interesting observations and particulars. We now proceed to the several kinds of oils.

CCCCLXXXVII. OILS (ANIMAL). All animal substances contain an oil, which is naturally unctuous, mild, and not volatile with the heat of boiling water. But, in general, the oil obtained from animals is in two very different states, which ought to be distinguished from each other.

The first state is that of butter and fat. This kind of animal oil is thick or congealed, and owes this quality to a considerable quantity of acid intimately combined with it, and which cannot be unfolded but by the action of fire, or by the rancidity it contracts in time.

The oil of animals, which is in form of butter or fat, is not combined with the other principles of animal matters. It is distinct from them, is superabundant to the animal composition, and is of a nature totally different from that which is combined with the animal substances. This superabundant animal oil, which may be called *adipous oil*, resembles perfectly wax, and those vegetable oils called properly *fat oils*; and, like these, it contains no other saline substance than an acid. The acid of these oily matters is more intimately combined than in other kinds of oils. Hence they are much less apt to become rancid, furnish less acid by repeated distillation, and are by this operation most difficultly rendered thin and volatile. *See* BUTTER, WAX, FAT, *and* OILS (FAT).

The oils of this kind which are contained in animals are fat, marrow, the expressed oil of yolks of eggs, spermaceti, and others of this nature.

The second state, in which the oil of animals is found, is in that of combination. The substance which forms almost entirely all the parts composing animal bodies, as flesh, tendons, nerves, cartilages, bones, horns, hair, &c. is gelatinous, perfectly soluble in water, and which does not disturb the transparency of water. This matter being distilled, furnishes a large quantity of oil, which is one of the parts of the decomposed substance. *See* JELLY. As this oil does not appear in the gelatinous matter before it has been decomposed, and as this matter is perfectly soluble in water, we may infer that oil is one of the principles of jelly, and is rendered perfectly miscible with water by means of the saline principles of that matter; it is consequently in a state perfectly saponaceous.

When the gelatinous matter has received no alteration, the oil which it contains appears absolutely mild, and is not so volatile as to rise with the heat of boiling-water; for fresh animal matters furnish nothing by distillation with that heat but water, excepting those which have peculiar smells; as musk, castor, and others of that nature. But if a stronger heat be applied, they then furnish much volatile alkali, and an oil; the first portions of which are thin, penetrating, and volatile. This is the oil which ought to be considered as the true animal oil. It has a smell strongly empyreumatic, disagreeable, and mixed with that of volatile alkali. This oil becomes more and more thick as it rises in distillation, as is usual in the distillation of all oils.

This animal oil differs essentially from fat, and from all vegetable oils. The cause of this difference seems to be, that the former oil does not appear to furnish a single particle of acid, but rather volatile alkali; whereas the latter oils contain an acid, which is unfolded and separated by distillation.

CCCCLXXXVIII.

CCCCLXXXVIII. OIL (ANIMAL) RECTIFIED, *or* OIL *of* DIPPEL. The animal oil described in the preceding article is susceptible, as other oils are, of being attenuated, and rendered more volatile, by repeated distillations. By a sufficient number of successive distillations, it may be rendered almost as white, thin, and volatile as ether. It is discovered to acquire a property of acting upon the brain and nervous system, and of allaying its irregular movements; which property is common to it with all other inflammable matters, when highly attenuated and very volatile. But this oil is particularly recommended for epileptic and convulsive affections. It is given from four to ten or twelve drops, incorporated with some proper vehicle.

The animal oil designed for medicinal uses must have the above-mentioned thinness, as Dippel has observed, whose name it retains: but it is then very dear, from the long and troublesome operations requisite to give it that thinness, and from the smallness of the quantity obtained. Besides, this oil, although perfectly well prepared, is very susceptible of losing its whiteness, and even its thinness, by a short exposure to air; which proceeds from the almost instantaneous evaporation of its more thin and volatile parts, and from the property which the less volatile remainder has of acquiring color. To avoid this inconvenience, it must be put, as soon as it is made, into very clean glass bottles, with glass stoppers, and exposed as little as possible to the air.

Although all animal substances contain this oil, they are not all equally fit for furnishing by distillation an oil capable of being rectified into a good oil of Dippel. For this purpose we ought to choose the parts of animals which contain the purest gelatinous substance, and which are entirely free from all fat; for the oil of fat, which necessarily mixes with the other oils in distillation, contains, as we have observed under the article OIL (ANIMAL), a large portion of acid intimately combined with it, from which it is very difficultly separable, and therefore is not nearly so easily attenuated as the true animal oil; besides that one of these oils has an acid, and the other an alkaline quality, and therefore their medicinal effects are probably different. Accordingly, as the flesh, bones, blood of animals, contain always some oily substance of the nature of fat or marrow, they ought not to be chosen for the preparation of the oil of Dippel. Horns, and particularly those of stags, which contain very pure gelatinous matter, are the animal substances from which the greatest quantity of this oil can be obtained in good condition.

The most important observations concerning the method of making the oil of Dippel are: First, to change the vessels each distillation, or else to clean them perfectly; for a very small quantity of the thicker and less volatile part is sufficient to spoil a large quantity of that which is more rectified. In the second place, Mr. Beaumé has observed, that this operation may be greatly abridged by taking care to receive none but the most volatile part in each distillation, and to leave a large residuum, which is to be neglected, and only the more volatile part is to be further rectified. By this method, we may obtain in three or four distillations a considerable quantity of fine oil of Dippel, which could not be obtained after 50 or 60 distillations, without attending to this circumstance.

CCCCLXXXIX. OILS (SWEET) *obtained from* VEGETABLES *by* EXPRESSION. Vegetable matters, at least many

many of them, contain an oil in two different ſtates, as animal matters alſo do; that is, in vegetables a certain quantity of oil is ſuperabundant to their combination, does not enter into the compoſition of their proximate principles, is diſtinct, and is depoſited as a reſerve in different parts of plants; and alſo in vegetables another quantity of oil is combined, and is one of the conſtituent parts of their proximate principles. Such are the ſaponaceous extractive ſubſtance, acids, eſſential ſalts, mucilaginous matters. Of the former of theſe vegetable oils we treat in this article. This ſuperabundant and uncombined oil, which may be obtained from certain vegetables, may be diſtinguiſhed into two kinds; one of which is acrid, volatile, and odoriferous, and is called *eſſential oil*; the other kind is mild, is not volatile with the heat of boiling water, and has ſcarcely any ſmell. Of this latter we ſhall firſt treat.

Moſt grains and kernels are the particular reſervoirs of this ſuperabundant oil. If theſe ſubſtances be bruiſed and pounded, this oil appears, and exſudes from them. By triturating them with water, the oil is reduced into the ſtate of an emulſion; and by expreſſing them, a very large quantity of oil is forced out of them.

When the grains and kernels from which oil is thus extracted are recent and preſerved from rancidity, the oil obtained has a very mild taſte. It is at firſt a little turbid, by mixture of ſome of the other parts of the grain or kernel; but theſe matters afterwards ſeparate in form of ſediment, and the oil becomes clear.

Theſe oils are never very fluid and thin; on the contrary, they are conſiderably unctuous. They are not ſo volatile as to riſe in diſtillation with the heat of boiling water, as we have already ſaid; and when they are expoſed to a heat ſo ſtrong as to raiſe them into vapors, they then ſuffer a conſiderable alteration. Although they are mild and inodorous, yet by diſtillation they become very acrid and very empyreumatic. Although they are combuſtible, yet they cannot be inflamed merely by the touch of a kindled body, as all thoſe inflammable matters may, which, by their volatility, are continually evaporating. Expreſſed oils cannot be inflamed without a wick, or without a heat ſufficient to evaporate them.

Sweet expreſſed oils ſuffer by time ſeveral alterations; they loſe much of their mildneſs, contract an acrimony, and a ſtrong ſmell. Theſe changes, which are called *rancidity*, are occaſioned by a kind of internal fermentation, which produces effects ſimilar to thoſe of fire, but much more ſlowly and weakly. The acid which is intimately combined with theſe oils, and which does not ſhow itſelf when they are recent and have not been altered, diſengages itſelf more and more as they become old, in the ſame manner as it does by expoſure to fire. This is the reaſon why they become acrid in both caſes: for the ſame reaſon alſo, they acquire ſo much greater ſolubility in ſpirit of wine, (which they had not before) as they have become more rancid, or have been more frequently diſtilled. Mr. Macquer has ſhewn, in his Memoir concerning the Difference of Solubility of Oily Subſtances in Spirit of Wine, that this entirely depends on the ſtate of the acid of theſe ſubſtances; that they are ſo much more ſoluble as their acid is more copious and diſengaged; and reciprocally. We ſhall find ſome particulars upon this ſubject at the article Essential Oil.

Of

Of all oils, thoſe of which we now treat are the moſt proper for combining with fixed alkalis, and for forming good ſoap (*ſee* SOAP); and alſo for diſſolving metallic matters.

All the ſweet ſuperabundant oils in vegetables, and which are capable of being extracted merely by expreſſion, reſemble each other by the general properties we have mentioned: but they differ conſiderably from each other by the degree in which they poſſeſs theſe and other properties. Some of theſe oils, as of linſeed, nuts, hempſeed, are diſpoſed to become rancid, to thicken, and to dry very quickly; they are capable of reſiſting a great degree of cold without being congealed; they form reſinous compounds when mixed with vitriolic and nitrous acids, and are eaſily inflamed by the ſmoking nitrous acid, as Mr. Rouelle has obſerved. Other oils, as thoſe of ben, olives, ſweet almonds, wallnut, &c. become much more ſlowly rancid and thick; they cannot be entirely dried; they congeal with a very ſlight degree of cold; they are leſs diſpoſed to combine with the vitriolic and nitrous acids; they form with theſe acids compounds, which rather reſemble fat or ſoap, as Mr. Beaumé remarks, than reſins; and, laſtly, cannot be inflamed, but by the concurrence of the vitriolic and nitrous acids highly concentrated. As theſe latter oils have, as to conſiſtence, a perfect reſemblance to *butter*, *fat*, and *wax* (*ſee theſe words*); and as they exhibit entirely the ſame phenomena, they juſtly deſerve to be diſtinguiſhed from all others by the particular denomination of *fat oils*.

In the claſs of theſe latter oils, we may range ſome concrete, oily, and mild matters obtained from vegetables; ſuch are the *butter of cacao*, the *green wax of Louiſiana*, and perhaps many others hitherto not ſufficiently examined. We may eaſily perceive, that among the great number of ſweet oils obtained by expreſſion, and which are not volatile, ſeveral of them muſt more or leſs partake of the nature of one or other of the two principal kinds we have juſt mentioned.

CCCCXC. OILS (ESSENTIAL). Thoſe oils are called *eſſential*, which have evidently the ſmell of the vegetable from which they are obtained. All theſe oils are ſufficiently volatile to riſe with the heat of boiling water: hence this degree of volatility is one of the ſpecific marks of theſe oils. They differ from all others, and particularly from thoſe mentioned in the preceding article, by this degree of volatility, which is peculiar to them.

We have reaſon to believe, that the greateſt part of the eſſential oil, which certain vegetables contain, is in a ſtate of combination, and makes part of ſome of their proximate principles. We are, however, certain, that many vegetables contain a ſuperabundant eſſential oil, uncombined, and depoſited as a reſerve in particular cells: ſuch is the oil which reſides in the rinds of oranges, lemons, citrons, in a word, of all fruits of that kind; which oil is ſo copious, that it may be obtained merely by expreſſion: ſuch probably are thoſe which are found moſt copiouſly and moſt manifeſtly in certain parts of plants; as the oil, for inſtance, which is found in the calix of roſes, but in too ſmall a quantity to be obtained by expreſſion alone.

However that be, as all eſſential oils are capable of riſing in diſtillation with the heat of boiling water; and as this degree of heat cannot occaſion any ſenſible alteration upon them (as may eaſily be ſeen by comparing the eſſential oil of citrons and others, obtained by expreſſion alone, with the oil of the ſame

vegetable extracted by a well managed diſtillation); by ſuch a diſtillation, therefore, may be obtained almoſt all the eſſential oils employed in chemiſtry and in the arts.

The moſt uſual and beſt method of obtaining the eſſential oil of a vegetable by diſtillation, is to take the plant in its prime of age, when its ſmell is the ſtrongeſt, and to chuſe thoſe parts of the plant in which the ſmell chiefly reſides; to put them in the cucurbit of an alembic without a water-bath; to add as much water as is ſufficient to prevent the plants from touching the bottom of the veſſel; to adjuſt a worm to the noſe of the alembic; and to give at once the degree of heat which is proper to make the water boil.

In this diſtillation, the water riſes impregnated with the ſmell of the plant, and it carries along with it all its eſſential oil. A part of this oil is ſo intimately mixed with the water which riſes in diſtillation, that it renders it turbid and milky; the reſt of the oil floats upon the ſurface of the water, or ſinks to the bottom, according to its ſpecific gravity. The diſtillation is thus to be continued, till we perceive that the water becomes clear; and more water muſt, from time to time, be put into the cucurbit, that the plant may be always kept moiſt with it. We ſhall ſee the reaſon of the ſeveral parts of this proceſs in the explanation of the particular properties of eſſential oils.

Not only theſe oils have all a ſtrong, aromatic ſmell, as we have already ſaid, but they have alſo a ſingular, and even an acrid and cauſtic taſte; in which reſpect they differ from the ſweet oils. This taſte proceeds from a copious and diſengaged acid, with which they are all penetrated.

The preſence of this diſengaged acid in eſſential oils appears from the impreſſion they make upon the corks of bottles, in which they are kept. Theſe corks are always ſtained of a yellow color, and a little corroded, nearly as they are by nitrous acid. Beſides, the vapor of theſe oils reddens blue paper; and the oils convert alkalis, with which they are triturated, into a neutral ſalt.

This acid is the cauſe of the ſolubility of eſſential oils in ſpirit of wine. They are not all equally ſoluble in this menſtruum, becauſe they do not all contain an equal quantity of acid. As this acid is almoſt diſengaged, and does not adhere ſtrongly in theſe oils, they loſe much of it by repeated diſtillations, and therefore their ſolubility in ſpirit of wine is leſſened by theſe operations; whereas ſweet oils, which, when recent, contain no diſengaged acid, and are therefore inſoluble in ſpirit of wine, become ſoluble in that menſtruum by diſtillation, which diſengages their latent acid, that was intimately combined with them; and this ſolubility may be encreaſed by repeating many times the diſtillation, as Mr. Macquer has proved in the Memoir quoted in the preceding article.

All eſſential oils are ſubject to loſe, by evaporation, their moſt volatile and thin part, in which the ſpecific ſmell of the vegetable, from which they are obtained, reſides; by which loſs they become thick, and acquire the conſiſtence and ſmell of turpentine, or even of reſins.

When in this ſtate, they are not, properly ſpeaking, eſſential oils, as they are no longer volatile with the heat of boiling water.

When eſſential oils, altered by time, but not yet entirely deprived of their peculiar ſmell, are diſtilled with the heat of boiling water, a part of them riſes in diſtillation, which has all the properties of eſſential oil freſhly diſtilled. As this

this portion of oil is renewed by this operation, it is frequently practiſed on eſſential oils, which begin to be altered by age; and this ſecond diſtillation is called the *rectification of eſſential oils.* We find in the cucurbit, after rectification, the reſinous portion of the oil, which is no longer capable of being raiſed by the heat of boiling water. This oily reſiduum may, however, be attenuated by diſtilling with a ſtronger heat, and even all the volatility and thinneſs of eſſential oils may be given to it, as alſo to all other oily matters, by diſtillations ſufficiently repeated. But ſuch oils have never the peculiar aromatic ſmell of the original eſſential oil.

From theſe properties of eſſential oil, we may conclude, that they receive their ſpecific character from their volatile odoriferous principle, that is, from the *ſpiritus rector* of the ſubſtance from which they were obtained; ſince they have the ſmell, thinneſs, and volatility which diſtinguiſh them, while they preſerve this principle, and loſe all theſe properties when it evaporates.

Theſe facts alſo ſhew the neceſſity of applying very quickly the degree of heat requiſite for the raiſing of theſe oils in diſtillation; for we may eaſily perceive, that as the ſpiritus rector is capable of riſing with a heat much leſs than that of boiling water, (which is neceſſary for raiſing eſſential oils) this ſpirit will riſe alone, when the heat is leſs than that of boiling water, and the quantity of eſſential oil obtained will be diminiſhed; ſo that if the diſtillation be continued with a leſs heat than that of boiling water, till the plant has loſt all the ſmell which it can loſe by this heat, no eſſential oil can then be obtained, or only a much leſs quantity of it.

As the ſpiritus rector is entirely ſoluble in water, therefore the water employed in this diſtillation of eſſential oils diſſolves a large portion of this ſpirit, and even becomes ſaturated with it. Accordingly, this water is much impregnated with the ſmell of the plant; but the oil by this means is in leſs quantity than it otherwiſe would be.

Hence we may infer, firſt, that no more water than is neceſſary ought to be employed; and, ſecondly, that the water which has thus riſen with the oil ought to be employed for other diſtillations preferably to pure water.

This water is not only much impregnated with the odoriferous principle of plants, but alſo it contains a conſiderable quantity of the thinneſt part of the eſſential oil, from which it receives a milky appearance. This portion of oil ſometimes remains a long time ſuſpended and half-diſſolved, by means of the ſpiritus rector: but, in time, a certain quantity of it is always ſeparated, which may be collected.

Eſſential oils are in general the moſt inflammable of all oils, becauſe they are the moſt volatile, and moſt eaſily reducible into vapors.

They unite more eaſily with acids than the ſweet oils which are not volatile. With theſe acids they form reſinous compounds, or are inflamed, according to the nature and degree of concentration of the acid employed.

They are more difficultly combinable than the ſweet oils which are not volatile, with fixed alkalis, with which they form a particular kind of ſoap. *See* SOAP *of* STARKEY.

Some conſiderable differences may be obſerved betwixt the ſeveral eſſential oils. Although, in general, they are all capable of riſing with the heat of boiling water, ſome of them, however, may be obtained in a larger quantity by

 a heat

a heat somewhat stronger; and this is effected by mixing with the water salts (as common salt) which are incapable of acting upon oils, and by means of which the water is capable of receiving a stronger heat.

The specific gravity of most of these oils is less than that of water, and accordingly they float upon the surface of this liquid. Some of these oils, however, are so heavy as to sink in water; of this kind are the essential oils obtained from the aromatic vegetables of hot countries, as cloves, cinnamon, sassafras, &c. To the distillation of these heavy oils a stronger heat is chiefly useful. Dry, woody, and compact matters, previously to the distillation of their essential oils, require the assistance of division and maceration during some days.

The consistence of essential oils varies much; some of them, as those of turpentine, sassafras, and citron, being very thin; and others, like those of aniseed and roses, have naturally much consistence, and are even congealed, unless they sustain a certain degree of heat.

Although the weight and consistence of essential oils proceed probably from the state of their acid, as well as all the other differences betwixt them, yet these two properties seem to be independent of each other; for some oils are, at the same time, very thin and very heavy, while others are very light and thick. The oil of sassafras, which is very fluid, is heavier than water; on the contrary, the oil of aniseed, the consistence of which is sometimes equal to that of congelation, floats upon water.

The quantity of essential oil obtained from different vegetables is very various. Some vegetable substances, as savin, turpentine, and most balsamic and resinous trees, furnish a large quantity of oil. From others, as roses, for instance, scarcely a sensible quantity of it is obtainable; and, lastly, others, although they contain much spiritus rector, and have much smell, furnish no essential oil by distillation: of this number are lillies, tuberoses, and jasmine.

Essential oils are employed in painting, in spirituous liquors used at the table and at the toilette, in perfumes, and in medicine. As they act very powerfully, small doses only are given internally, as from one drop to four or five, incorporated with sugar, so as to form an oleosacharum, or with other drugs in form of pills.

These oils being inflammable, thin, and volatile, have in general a property of acting upon the nervous system, and of allaying its irregular movements: it is therefore given as a cephalic, and antispasmodic, in convulsive and hysterical affections; they are also stimulant, sudorific, and strengthening. All drugs which are alexipharmac, cephalic, tonic, and stomachic, which contain vegetable aromatics, derive their virtues from the essential oils of these vegetables. The same may be said of all medicinal, aromatic, and spirituous waters.

In some cases, essential oils are employed externally as strengtheners, and to allay painful spasms of nervous and tendinous parts, to resolve and dissipate acrid humors, which occasion pain without any sensible sign of inflammation. When essential oils are applied externally in these cases, they are so caustic that they must not be applied alone, as they would excite pain, redness, frequently inflammation, erysipelatous eruptions, and excoriations. They are a kind of vesicatory. The best method of avoiding these inconveniences is, by mixing them

them with a sufficient quantity of fat, or of fat oil, to form liniments or pomatums, with which the diseased parts may be rubbed.

The essential oils, which are obtained from scarce and valuable substances, must also be very dear, and are therefore subject to much adulteration. Most of the books of chemistry explain the manner of making, or of discovering these adulterations. We shall only, in a summary manner, mention what is most important to be known on this subject.

Essential oils may be adulterated with any flavorless fat oil, with spirit of wine, or with any common and cheap essential oil. They who know the properties of these substances may easily discover the fraud. As fat oils are neither volatile nor drying, if a drop of the essential oil, to be examined, be put upon paper, it may be evaporated with a gentle heat; and when it is unmixed with fat oil, it will leave no greasiness nor transparency in the paper. This mixture may also be discovered by mixing a drop of the essential oil with spirit of wine, by which it will be entirely dissolved if it be pure from fat oil; but if it has been adulterated with this latter kind of oil, this will remain undissolved in spirit of wine.

The mixture of spirit of wine with an essential oil may be discovered by addition of water, which immediately acquires a milky appearance; because the spirit of wine quits the oil to unite with the water, and leaves the oil much divided and suspended, but not dissolved. This does not happen when the essential oil has not been adulterated with spirit of wine. Pure essential oil may, indeed, by agitation with water, be divided into small globules, and may give a whiteness to the water: but these globules quickly unite again on the surface, or at the bottom of the water, according to their specific gravity.

Lastly, adulteration by another essential oil is most difficultly discoverable; because the principal properties of these oils are common to all. Nevertheless, as essential oils are commonly adulterated with oil of turpentine, this fraud may be discovered by soaking a bit of paper or linen with the oil to be examined, and by quickly evaporating the oil, which will leave upon the linen or paper a strong smell of turpentine.

CCCCXCI. OILS (FETID, EMPYREUMATIC). Under this name we comprehend all the oils of vegetable and animal matters obtained by distillation with a heat superior to that of boiling water; because these oils have a disagreeable, burnt, or empyreumatic smell.

From this definition we see, that empyreumatic oils are not a distinct class; that they may be very different from each other, and may have nothing in common, but that they are all half-burnt; for when any vegetable or animal matter is exposed to a degree of heat superior to that of boiling water, all the oils which they contain, of whatever kind they may be, pass in distillation; but are altered, by the fire, in their color, smell, and in many other of their peculiar properties. Besides, if the matter thus distilled contains several kinds of oils, they are all mixed together when they are rendered empyreumatic. If, for example, a vegetable matter be distilled, which contains an oil that is sweet and not volatile, and also an oil in a resinous state, the fetid empyreumatic oil obtained will be only a mixture of these two oils half-burnt. The same may be said of animal matters with regard to the oil properly called animal oil, and to the adipous oil which they contain.

No general properties, then, can be established as belonging to empyreumatic oils: they all vary according to the nature and proportion of the oils of which they are composed. Hence, if we would know the properties of any empyreumatic oil, we must previously know the kinds and proportion of oils contained in the substance from which it has been obtained, and also the changes suffered by each of these oils by the degree of heat requisite to render them empyreumatic. We shall here only observe, that all empyreumatic oils are acrid, and more or less soluble in spirit of wine; that the portion of these oils which rises first in distillation is always the thinnest; that by repeated distillations they may be rendered more and more thin and volatile; and that by a sufficient repetition of these rectifications, we may almost entirely deprive them of their empyreumatic smell, so that only a pungent and penetrating smell shall remain; which seems to be common to all oils treated in this manner.

CCCCXCII. O I L S, *improperly so called.* Many preparations were by the ancient chemists called *oils*, merely from their consistence, although in other respects they were entirely different from oil. These improper names ought to be abolished, and they are accordingly falling into disuse by modern chemists. Nevertheless, as they are found in most chemical books in the time of Lemeri, and as many of them are still frequently employed, we shall explain in a few words the chief of them.

CCCCXCIII. O I L *of* A N T I M O N Y. By this name the butter of antimony, and some other solutions of antimony by acids, are called. *See* Butter *of* Antimony.

CCCCXCIV. O I L *of* A R S E N I C. This is a combination of concentrated marine acid with arsenic, and is made precisely in the same manner as butter of antimony. Equal parts of arsenic and of corrosive sublimate are mixed and distilled together, by which a liquor is distilled, similar to the butter of antimony. This is a very powerful, but, at the same time, very dangerous caustic. This shews, that arsenic, like regulus of antimony and several other metallic substances, is capable of decomposing corrosive sublimate by seizing its acid. Accordingly, mercury is revived in this as in all the similar operations.

CCCCXCV. O I L *of* M E R C U R Y. When water is added to a solution of mercury in vitriolic acid to form the precipitate called *turbith mineral*, the acid thus diluted still retains a portion of mercury dissolved, which is properly a vitriol of mercury. This salt, which is crystallizable, may be obtained by evaporating the water which keeps it dissolved. When exposed to a moist air, it deliquiates into a liquor which Lemeri calls *oil of mercury*. *See* Turbith Mineral.

Lemeri also gives the name of *oil of mercury* to a solution of corrosive sublimate in spirit of wine.

CCCCXCVI. O I L *of* L E A D. This is a solution of salt of lead in the essential oil of turpentine. This salt is to be put into a matrass, and upon it oil of turpentine is to be poured, till it covers the salt with a thickness of some fingers, and the whole is to be digested during ten or twelve hours. The liquor, says Lemeri, acquires a red color. That author directs that the solution should be concentrated, by distilling from it a part of the oil of turpentine; and he recommends it for its utility in cleansing and cicatrising ulcers, particularly

ticularly those which are putrid. This preparation, which is certainly a powerful antiseptic, must be very proper for these purposes.

Amongst the oils improperly so called, this is one of those to which the name of oil has been with least impropriety given; for the basis of it is actually oil, and that oil really keeps the lead in solution. Lemeri affirms, that we may thus entirely dissolve a given quantity of salt of lead, by employing a sufficient quantity of oil of turpentine. This preparation, which has only been made for medicinal purposes, is interesting also in chemistry, and deserves a particular examination.

CCCCXCVII. OIL *of* SULPHUR. Some chemists have given this name to the concentrated acid of sulphur. *See* SULPHUR.

CCCCXCVIII. OIL *of* TARTAR *by* DELIQUIUM. This name very frequently is given to fixed alkaline salt resolved into a liquor by the moisture of the air, or even to a solution of that salt in water. This name is unsuitable, not only as this liquor is not of the nature of oil, but also because a true oil of tartar is obtained by distillation of tartar. This liquor ought to be called *alkali of tartar*, or *liquid vegetable alkali*. *See* ALKALI (FIXED VEGETABLE), *and* TARTAR.

CCCCXCIX. OIL *of* VENUS. Lemeri gives this name to the salt formed by the union of copper with the nitrous acid, when it is resolved into a liquor by the moisture of the air. It is a caustic and escharotic, like all other similar combinations of metallic matters with any acids to which the name of oil was formerly given. An empyrical physician has rendered this name of oil of Venus famous in these latter times, by having applied it to a ratafiat of his composition, which has been found agreeable, and has been much in vogue.

D. OIL *of* VITRIOL. This name is very commonly, but improperly, given to concentrated vitriolic acid. *See* ACID (VITRIOLIC), *and* VITRIOL.

DI. OLEOSACHARUM. This name is given to a mixture of oil and sugar incorporated with each other, to render the oil more easily diffusible in watery liquors. Sugar and all saccharine matters have in general a quality somewhat saponaceous, and consequently are capable of producing this effect in some measure. These oleosacharums are used in pharmacy as a method of administering essential and other oils. *See* OILS *and* JUICES (SACCHARINE).

DII. OLIBANUM. *(s)*

DIII. ONIONS. *(t)*

DIV. OPAL. *(u)*

(*s*) OLIBANUM, *thus*, *frankincense*, is a gum-resin, of an ounce of which water is capable of dissolving three drams and a scruple, and spirit of wine is capable of dissolving five drams and two scruples. *Neuman.*

(*t*) ONIONS. This root has an essential oil, which impregnates water in distillation with a very strong smell, and which is so miscible with the distilled water, that it cannot be collected separately. The oil may also be combined with spirit of wine by distillation. From an ounce of the dry root six drams of extract may be obtained by spirit of wine, and somewhat more may be obtained by water. *Neuman.*

(*u*) OPAL is an almost pellucid agate, the color of which varies by reflexion and refraction. Opals are milk-colored, blackish, yellowish, or greenish; which latter variety is

DV. ONYX. (*x*)
DVI. OPIUM. (*y*).
DVII. OPOPONAX. (*z*)
DVIII. ORANGE. (*a*)
DIX. ORES. Ores are natural compounds, containing metals allayed with different ſubſtances.

Excepting gold, and a very ſmall quantity of each of the other metals found in ſome places ſo pure as to poſſeſs all their characteriſtic properties, nature exhibits to us metals and ſemimetals differently allayed not only with each other, but alſo with ſeveral heterogeneous ſubſtances, which ſo alter and diſguiſe their qualities, that in this ſtate they cannot ſerve for any of the purpoſes for which they are proper when they are ſufficiently pure.

The ſubſtances found naturally combined with metals, in the earth, are, particularly, ſulphur and arſenic, ſometimes ſeparately, but generally conjointly.

is called *cats eye*. Opals are claſſed among the ſiliceous order of earths, although ſome of them are ſo ſoft as to be capable of being ſcratched with a knife. The *oculus mundi* is a rare but curious variety of the opal. It is opake, and generally of a yellowiſh color; but by being immerſed during ſome hours in water, becomes tranſparent, and acquires a bright yellow, or even a luminous flame-color.

(*x*) ONYX is an agate, generally opake, or but ſlightly tranſparent, conſiſting of differently colored veins, parallel to each other, ſometimes in ſtraight and ſometimes in curve lines. *See* AGATE.

(*y*) OPIUM is almoſt totally ſoluble in water or in ſpirit of wine. It contains a reſin, a gum, a minute portion of ſaline acidulous matter, water, and earth. On what its peculiar properties depend we do not well know. When opium is diſſolved in water, a fat, frothy, reſinous ſubſtance riſes to the ſurface, which is ſo ſtrong and active, that a *few* grains of it are ſufficient to kill a dog who could bear a whole dram of opium. From a pound of opium two or three drams only of this ſubſtance may be collected; but the opium contains more of it, which remains combined with the reſt of the juice. The narcotic matter of the opium appears to be diffuſed through all its ſubſtance, but more eſpecially to reſide in the fine volatile parts; which parts are capable of being highly concentrated by art. Neuman (from whom the above is extracted) ſays, that he knows a preparation of opium by which a whole chamber full of men may be preſently ſtupefied, deprived of their ſenſes, and even of their lives, without ſwallowing a ſingle grain. He thinks that it operates nearly in the ſame manner as the vapor of burning charcoal, or as the exhalations of fermenting liquors. The ſame author propoſes to render opium more mild and innocent, by diſſolving it in water and fermenting the ſolution. Dr. Lewis obſerves, that diminiſhing the doſe of opium is a more certain method of diminiſhing its effects. He alſo ſays, that alkaline ſalts diminiſh the ſoporific power of opium, and that acids almoſt totally deſtroy it.

(*z*) OPOPONAX is a gum-reſin, of an ounce of which two drams and two ſcruples are ſoluble by ſpirit of wine, and three drams two ſcruples are ſoluble by water. Both water and ſpirit, by diſtillation with opoponax, acquire its flavor; but no oil is thereby ſeparated. *Neuman.*

(*a*) ORANGE. The flowers of orange trees afford, by diſtillation, a very fragrant eſſential oil. From the rind of the fruit an eſſential oil may be obtained by expreſſion. The juice of the fruit contains an eſſential acid ſalt, mixed with much mucilage. This ſalt may be obtained in cryſtals, by diluting the juice, clarifying it with whites of eggs, and evaporation. The juice, not depurated from its mucilage, is apt to become mouldy; but by the above-mentioned method of depuration, a ſaline extract may be made, capable of being preſerved, and poſſeſſed of the ſame medicinal qualities as the juice, which is ſaid to be very powerful in the ſcurvy.

Metals

Metals combined with theſe ſubſtances are called *metals mineraliſed by ſulphur*, or *by arſenic*, or *by ſulphur and arſenic*; and theſe matters are called *mineraliſing* ſubſtances.

Beſides the ſulphur and arſenic with which metals are ſtrictly combined in the mineral ſtate, they are alſo pretty intimately combined with earthy ſubſtances, of different natures, and more or leſs divided. A part of this earth is diſpoſed to metalliſation, and is convertible into a metal by combination with phlogiſton. It is called *metallic earth*, and probably proceeds from a portion of metal which has been decompoſed, and deſtroyed in its ore by different cauſes, which we ſhall mention afterwards. Perhaps alſo this earth may be only a ſimple earth naturally diſpoſed to metalliſation, or the firſt beginning of a metal which nature has not yet brought completely to a metallic ſtate.

We are to obſerve upon the ſubject of this metallic earth, that it is found not only amongſt mineraliſed metals, but that it appears diffuſed, although in very ſmall quantity, in large maſſes of ordinary earth which is found every where, ſuch as ſands, clays, and mud. Mr. Cramer thinks that the experiments mentioned by Becher in his third Supplement to his *Phyſica Subterranea*, by which he extracts gold or iron from any ſands or clays, are demonſtrative upon this ſubject. The other portion of earth which is intimately mixed with mineraliſed metals, cannot be reduced into metals, and is therefore called *unmetallic earth*. This is an ordinary earth.

Theſe different matters united together form maſſes which are compact, heavy, brittle, and frequently poſſeſſed of much metallic luſtre. Theſe ſubſtances are properly called *ores*, or the matter of mines.

Theſe ores are found in earths and ſtones of different kinds, as ſands, flints, cryſtals, ſlates, indurated clays, according to the ground in which they are contained. But two kinds of ſtones in particular ſeem to accompany ores, and have therefore been conſidered by ſeveral mineralogiſts as matrixes, in which metals are formed. One of theſe ſtones is a kind of cryſtal, generally white, milky, and ſemi-opake, ſtriking fire with ſteel, and of the claſs of vitrifiable earths. It is called *quartz*. *See* QUARTZ.

The other ſtone is leſs hard, which does not ſtrike fire with ſteel, and is ſometimes milky like quartz; ſometimes tranſparent and diverſely colored, conſiſting of rhomboidal cryſtals, which are compoſed of plates and faces. This ſtone becomes more ſoft and friable by being expoſed to fire. It is called *ſpar*. Spar is more like to gypſeous ſtones than to any other, but it differs from gypſeous ſtones in poſſeſſing a much greater denſity. Some ſpars are ſo heavy, that they exceed in this reſpect all other ſtones. *See* SPAR.

Theſe earthy and ſtoney ſubſtances ought to be well diſtinguiſhed from the earth intimately mixed with the ore, as is mentioned above; this latter earth conſtituting part of the ore, whereas the others are only accidental, and externally adherent. They form the *matrix of the ore*.

Mines have generally the form of veins, or of congealed currents, which have different directions, and which are diſtributed in branches. The mines take different appellations according to the direction of their veins.

The *deep mines* are thoſe which deſcend from the ſurface of the earth, either vertically, or more or leſs obliquely towards its center.

Those which are extended horizontally are called *dilated mines*, because they frequently are considerably broad.

Some mines compose masses more or less extensive, and almost equally long, broad, and thick. These latter are called *accumulated mines*.

Some authors have said that the veins of mines are always directed from east to west, from north to south, or in the intermediate directions, according to the nature of the metals. But this opinion is not well supported by facts; for we are certain that veins of every metal run in every direction. The direction of mines is determined by their descent, like that of rivers, and by help of a mariner's compass.

From several signs we may know that a field or a mountain contains a mine, particularly when the mine is near the surface of the earth. For, from grounds filled with minerals, sulphureous and metallic vapors rise, which are sometimes so considerable as to affect the senses, but which most frequently only shew themselves by the effects which they produce on plants, which they render weakly, and discolored. Frequently even, mineralogists say, these places are entirely barren, and no vegetables grow there, although the ground seems to be of a good quality, and fit for vegetation.

The sources of mineral waters; the nature of the stones upon the ground being that of quartz or spar; bits of minerals lying on the ground; are so many proofs of the presence of mines.

But we must not altogether depend on these signs; for notwithstanding them, we often find no mines, or very poor ones, when we dig the ground.

The digging of the ground is then the only certain method of determining the existence of a mine, and of what kind it is; for the *wand of divination*, by which many pretend that mines and their quality may be discovered, is a chimera, which owes its reputation to credulity and ignorance.

Metallic minerals are divided into two classes. The first includes all those, in which the quantity of metal exceeds the quantity of sulphur, arsenic, and unmetallic earth; or from which metal may be advantageously extracted. These minerals are particularly called *ores*.

In the second class are placed all minerals which contain more sulphur, arsenic, and unmetallic earth than metal; and these in general are called *pyrites*.

Pyrites and ores are of the same nature, and are often both found in the same places. But as the proportion of the principles of these compounds is different, their properties also differ. We shall explain the properties of pyrites under the article *pyrites*, and the properties of ores in this present article.

Ores may be considered in two ways; first, as containing useful and valuable substances, and they then receive their name from the most valuable metal which is obtained from them. Thus, for instance, as silver is much more valuable than lead, a mineral, a quintal of which contains a mark of silver, and sixty pounds of lead, or more, is called *an ore of silver*, because the mark of silver is more valuable than the 60 pounds of lead. This manner of denominating ores is chiefly used by the miners.

In the second place, we may chiefly attend to the metal the largest quantity of which is contained in a mineral, without attending to its value, and affix its name to the ore. In this manner, the ore just now mentioned would be called

called *an ore of lead*, and not *an ore of silver*. But the best method seems to be, to call such an ore *an ore of lead containing silver*, as is very frequently done.

Mr. Cramer, a profound and judicious chemist, who has particularly attended to this subject, thinks that we ought to call an ore, the *proper ore of that metal* which it contains in largest quantity, and to call it the *improper ore* of all the other metals it may contain. This method of distinguishing ores is certainly one of the best and most exact. We shall now give a summary description of the principal kinds of ores of each metallic substance. (*b*).

(*b*) As metallurgy is the most important part of chemistry, we hope that a *sketch of the History of Mines*, and a more particular *enumeration of ores* than is contained in the text, together with a relation of the most approved methods of extracting metals from ores, for the purposes of *essay*, or of *commerce* and *manufacture*, may be not unacceptable. In the present Note, we shall treat of mines, and of ores in general: Under the articles in the text, which treat of the ores of the several metals, we shall subjoin an enumeration of those which are there omitted, and also the methods of essaying the several ores to discover the quantities and qualities of their contents: Lastly, under the article, SMELTING *of* ORES, we shall make some additions concerning the methods of extracting metals from large quantities of ores for the purposes of commerce and manufacture.

Concerning ORES *and* MINES.

ORES consist, 1. Of metallic substances *calcined*; or, 2. Of these substances combined with other matters, with which they are said to be *mineralised*.

Calcined metallic substances, or *calciform ores*, are metallic substances deprived of phlogiston, and in the state of a calx, or metallic earth. *See* CALX. Such are all *ferruginous ochres*, which are calxes of iron.

Mineralised ores are, 1. *Simple*, containing only one metallic substance: or, 2. *Compound*, containing two or more metallic substances.

Of the simple, and also of the compound ores, four kinds may be distinguished.

1. Ores consisting of metallic substances mineralised by *sulphur*. Such is the lead-ore called *galena*, composed of lead and sulphur.

2. Ores consisting of metallic substances mineralised by *arsenic*. Such is the *white pyrites*, containing iron and arsenic.

3. Ores consisting of metallic substances mineralised *by sulphur and by arsenic*. Such is the *red silver-ore*, containing silver, arsenic, and sulphur.

4. Ores consisting of metallic substances mineralised by *saline matters*. Such are the *native vitriols*. Such also is probably the *corneous silver-ore*, which, according to Mr. Cronstedt's opinion, is a luna cornea, or silver combined with marine acid. Of this kind of ores, or native metallic salts, is perhaps the *sedative salt of borax*, which appears, from Mr. Cadet's experiments, published in the Memoirs of the Royal Academy for the year 1766, to be copper combined with marine acid, and which has been said to be found native. To this class also may be referred the *silver mineralised by an alkaline substance*, which Mr. Von Justi pretends to have discovered.

Henckel, and after him Cramer, and the author of the Dictionary of Chemistry, pretend that in mineralised ores, besides the above-mentioned metallic and mineralising substances, are also contained a metallic and an unmetallic earth. But Wallerius affirms, that the existence of such earths cannot be shewn, and that sulphur is incapable of dissolving unmetallic earths, and even the calxes of all metallic substances, excepting those of lead, bismuth, and nickel.

Having thus defined and distinguished the several general classes of ores, we proceed to shew how they are lodged, and where they are found.

Metals and *metalliferous ores are found* in various places. I. They are found *under water*; in beds of rivers, lakes and seas, and chiefly at the flexures of these: Such are the

DX. ORES *of* GOLD. In taking the word *ore* in the ſenſe above-mentioned, no ores of gold exiſt: for as this metal cannot be allayed

the auriferous and ferruginous ſands, grains of native gold, ochres, and fragments of ores waſhed from mines.

II. They are found *diſſolved in water*: Such are the vitriolic waters containing iron, copper, or zinc.

III. They are found *upon the ſurface of the earth*. Such are many ochres; metalliferous ſtones, ſands, and clays; and lumps of ores. Mr. Gmelin ſays, that in the northern parts of Aſia, ores are almoſt always found upon or near the ſurface of the ground.

IV. They are found *under the ſurface of the earth*. When the quantity of theſe collected in one place is conſiderable, it is called a *mine*.

Subterranean metals and ores are differently diſpoſed in different places.

1. Some are *infixed in ſtones and earths*, forming *nodules* or *ſpots* diverſely colored.

2. Some are equably and *uniformly diffuſed through the ſubſtance of earths and ſtones*, to which they give color, denſity, and other properties. Such are the greateſt part of thoſe earths, ſtones, ſands, clays, cryſtals, flints, gems, and fluors, which are colored.

3. Some form *ſtrata* in mountains. Such are the ſlates containing pyrites, copper-ore, lead-ore, ſilver-ore, or blend. Theſe lie in the ſame direction as the ſtrata of ſtones betwixt which they are placed, but they differ from the ordinary ſtrata in this circumſtance, that the thickneſs of different parts of the ſame metalliferous ſtratum is often very various; whereas the thickneſs of the ſtoney ſtrata is known to be generally very uniform.

4. *Fragments of ores* are frequently found accumulated in certain ſubterranean cavities, in fiſſures of mountains, or interpoſed betwixt the ſtrata of the earth. Theſe are looſe, unconnected, frequently involved in clay, and not accreted to the contiguous rocks or ſtrata immediately, nor by intervention of ſpar or of quartz, as the ores found in veins are. Tin and iron mines are frequently of the kind here deſcribed.

5. Large entire maſſes of ores are ſometimes found in the ſtoney ſtrata of mountains. Theſe are improperly called *cumulated veins*, becauſe their length relatively to their breadth and depth, is not conſiderable.

6. Some inſtances are mentioned of *entire mountains* conſiſting of ore. Such is the mountain Taberg in Smoland; and ſuch are the mountains of Kerunavara and Luoſavara in Lapland, the former of which is 1400 perches long, and 100 perches broad. Theſe mountains conſiſt of iron-ore.

9. Laſtly, and chiefly, metals and ores are found in oblong tracts, forming maſſes called *veins*, which lie in the ſtoney ſtrata compoſing mountains.

The direction of veins greatly varies; ſome being ſtraight, and others curved. Their poſition alſo reſpecting the horizon is very various; ſome being perpendicular, ſome horizontal, and the reſt being of the intermediate degrees of declivity.

The dimenſions, the quality, and the quantity of contents, and many other circumſtances of veins, are alſo very various. Miners diſtinguiſh the ſeveral kinds of veins by names expreſſive of their differences. Thus veins are ſaid to be *deep*; *perpendicular*; *horizontal*, or *hanging*, or *dilated*; *rich*; *poor*; *morning*, *noon*, *evening*, and *night* veins, by which their direction towards that point of the compaſs where the ſun is at any of theſe diviſions of the natural day, is ſignified.

The ſtratum of earth or ſtone lying above a vein is called its *roof*: and the ſtratum under the vein is called its *floor*.

Some parts of veins are conſiderably thicker than others. Small veins frequently branch out from large veins, and ſometimes theſe branches return into the trunk from which they iſſued. Theſe veins, from which many ſmaller veins depart, have been obſerved to be generally rich.

Veins are terminated variouſly; 1. By a gradual diminution, as if they had been compreſſed, while yet ſoft, by ſuperincumbent weight; or by ſplitting and dividing into ſeveral ſmaller veins: or, 2. They are terminated abruptly, together with their proper ſtrata in which they lie. This abrupt termination of veins and ſtrata is occaſioned by their being croſſed by new ſtrata running tranſverſely to the direction of the former; or by perpendicular fiſſures through the ſtrata; which fiſſures are frequently

with arſenic, nor with ſulphur, it is never found directly mineraliſed by theſe ſubſtances, as the other metals are. In the ſecond place, if it be mineraliſed

quently filled with alluvial matters, or with water, or are empty. Theſe perpendicular fiſſures ſeem to have been occaſioned by ſome rupture or derangement of the ſtratum through which the vein paſſes, by which one part of it has been raiſed or depreſſed, or removed aſide from the other, probably by earthquakes. Where the vein is terminated abruptly, it does not ceaſe, but is only broken and disjoined; and is often recovered by ſearching in the analogous parts of the oppoſite ſide of the deranged ſtratum. A principal part of the art of miners conſiſts in diſcovering the modes of theſe derangements from external marks, that they may know where to ſearch for the disjoined vein.

The *contents of veins* are metals and metalliferous minerals, as, the ſeveral kinds of ores, pyrites, blends, guhrs, vitriols; the ſeveral kinds of fluors, ſpars, quartz, hornblend, in which the ores are generally imbedded, or inveloped, and to which therefore the name, *matrix of the ore*, is applied; ſtalactites; cryſtallizations of theſe metalliferous and ſtoney ſubſtances encruſting the ſmall cavities of the circumjacent rock; and laſtly, water, which flows or drops through crevices in that rock.

In a vein, ores are found ſometimes attached to the rock or ſtratum through which the vein runs, but more frequently to a matrix which adheres to the rock; and ſometimes both theſe kinds of adheſion occur in the ſame vein at different places. Frequently betwixt the matrix and the rock is interpoſed a thin cruſt of ſtone or of earth, called by authors the *fimbria of the ore*.

The *matrix* or the ſtone in which the ore lies inveloped is of various kinds in different veins. And ſome kinds of ſtone ſeem better adapted than others to give reception to any ore, or to the ores of particular metals. Thus quartz, ſpar, fluors, and hornblend give reception to all ores and metals; but ſlates, chiefly to copper and ſilver, and never to tin; calcareous and ſparry matrixes, to lead, ſilver, and tin; and mica to iron.

Veins lie in ſtrata of different kinds of ſtone; but more frequently in ſome kinds of ſtone than in others. Thus of the ſimple or uncompounded ſtones which compoſe ſtrata, the following are metalliferous: *calcareous ſtones*; *ſlaty ſand-ſtone* (cos fiſſilis arenoſus Wallerii); *feltſpar* (ſpatum pyrimachum ſive ſcintillans); *quartz*; ſometimes *jaſper*; frequently *ſlates*; and chiefly *micaceous* or *talky* ſtones; and *hornblend* (lapis corneus Wallerii; bolus indurata particulis ſquamoſis Cronſtedt). No veins have been found in gypſeous or in ſiliceous ſtrata, altho' *chertz* and *flints* frequently contain metallic particles, and ſome inſtances have been obſerved of ores of ſilver and of tin in *alabaſter*. Of compound ſtones, thoſe are ſaid to be chiefly metalliferous which conſiſt of particles of hornblend. Veins have alſo been found in the *red granite*; but ſeldom, if ever, in any other *granite*, or in *porphyry*. In general, veins are more frequently found in ſoft, fiſſile, and friable ſtrata, than in thoſe which are compact and hard.

A vein ſometimes paſſes from one ſtratum into the inferior contiguous ſtratum. Sometimes even the veins of one ſtratum do ſo correſpond with thoſe of an inferior ſtratum, the contiguity of which with the former is interrupted by a maſs of different matter through which the veins do not paſs, that they ſeem originally to have been continued from one ſtratum to the other. Thus in the mines of Derbyſhire, where the veins lie in ſtrata of limeſtone, the contiguity of which ſtrata with each other is interrupted in ſome places by a blue marle or clay, and in other places by a compound ſtone called *toadſtone*; the veins of one ſtratum frequently correſpond with the veins of the inferior ſtratum of limeſtone, but are never continued through the interpoſed clay or toadſtone. But we muſt obſerve, that theſe interpoſed maſſes, the blue marle, clay, and toadſtone, have not the uniform thickneſs obſervable in regular ſtrata, but are (eſpecially the toadſtone) in ſome places a few feet in depth, and in others ſome hundreds of yards. The above diſpoſition ſeems to indicate, that theſe ſeveral ſtrata of limeſtone have been originally contiguous; that the veins now disjoined have been once continued; that theſe ſtrata of limeſtone have been afterwards ſeparated by ſome violent cauſe, probably by the ſame earthquakes which have in a ſingular man-

indirectly by the union it contracts with other metals naturally combined with sulphur and arsenic, so small a quantity of it only is found in these ores, that they scarcely even deserve the name of *improper ores of gold*.

ner shattered the strata of this mountainous country; that the interstices thus formed between the separated strata have been filled up with such matters as the waters could insinuate, probably with the mixed comminuted ruins of shattered strata; and, lastly, that these shattered strata have consisted of argillaceous and of calcareous earths, as appears from the clay; from the marle, which is a mixture of clay and calcareous earth; and from the toadstone, which consists of particles of hornblend (which Mr. Cronstedt justly considers as an indurated bole or clay) mixed with particles of calcareous earth.

To the above historical sketch of mines we shall add some conjectural remarks concerning their *formation*.

Those ores which are found under water (I.); upon the surface of the earth (III.); in fissures of mountains and subterranean cavities, accumulated, but not accreted to the contiguous rocks, (IV. 4.) seem from their loose, unconnected, broken appearance, to have been conveyed by alluvion.

All martial ochres have probably been separated from vitriolic ferruginous waters (II.) either spontaneously or by calcareous earth; and these waters seem to have acquired their metallic contents by dissolving the vitriol which is produced by the spontaneous decomposition of martial pyrites. The ochres of copper, zinc, and perhaps of several other metals, have probably been precipitated from vitriolic waters by some substance, as calcareous earth, more disposed to combine with acids; and these vitriolic waters have probably been rendered metalliferous, by dissolving the vitriols produced by a combustion of cupreous pyrites, and of blend; for these minerals are not, as martial pyrites is, susceptible of decomposition, spontaneously, or by air and moisture.

The metalliferous nodules and spots (IV. 1.) seem to have been infixed in stones while these were yet soft. Perhaps the metalliferous and lapideous particles were at once dissolved and suspended in the same aqueous menstruum, and during their concretion, crystallized distinctly, as different salts do, when dissolved in the same fluid.

The earths and stones uniformly colored by metals (IV. 2.) were also probably in a soft state while they received these tinges. The opake-colored stones seem to have received their color from metallic calxes mixed and diffused through the soft lapideous substance; and the transparent-colored stones have probably received their colors from vitriolic salts, or from metallic particles dissolved in the same water which softened or liquefied the stony substance; which metallic salts and particles were so much diffused, that they could not be distinctly crystallized. That all stones have been once liquid and dissolved in water, appears probable not only from their regular crystallized forms, but also from the solubility of some stones, as of gypseous and calcareous earths, in water; and from the water which we know is contained in the hardest marbles, as well as in alabasters; to which water these stones owe the crystallization of their particles.

The veins called *cumulated*, (IV. 5.) and the entirely metalliferous mountains (IV. 6.) are believed by Wallerius to be analogous to the nodules (IV. 1.). These metalliferous substances seem to have been originally formed or concreted in the places where they are found.

The metalliferous strata (IV. 3.) have probably been insinuated between the lapideous strata, after the separation of these from each other by some violent cause; in the same manner in which we supposed that the clay and toadstone have been insinuated betwixt the several strata of limestone in Derbyshire. The matters thus insinuated may have been either fluid, which would afterwards crystallize, and form entire regular masses; or they may have been the ruins of shattered strata and veins brought by waters, and there deposited; in which case they will appear broken and irregular. These metalliferous strata, although frequently confounded with the horizontal or dilated veins, may be distinguished, according to Wallerius, from these by the following properties: 1. They are generally thinner and much broader than the veins called dilated. 2. They are seldom found at a greater depth than a hundred perches, and generally in the neighbourhood of

Hence gold is found either in its natural ſtate, of a certain degree of purity, poſſeſſed of all its properties, or engaged with ſome other metals in certain minerals.

of veins, from which they probably have received their contents. 3. From their want of the thin encruſtations called *fimbriæ*, which, we obſerved, are frequently interpoſed betwixt the rock and the ore or its matrix; and from their want of the other properties of veins.

But in *veins*, properly ſo called, the ſtrongeſt marks exiſt of ores having been there concreted, and not depoſited in their preſent ſtate. Their regular, unbroken appearance, their accretion to the contiguous rock, either immediately or by intervention of a matrix, the regular appearance of this matrix inveloping the ore, the frequent cryſtallization of the ore and of the other contents of the vein, indicate, that ores, as well as the other ſolid contents, have been there concreted from a fluid to a ſolid ſtate.

Moſt authors believe, that veins, and the perpendicular clefts in the ſtony ſtrata of mountains, called *Fiſſures*, have been produced by the ſame cauſe; or rather, they conſider veins only as fiſſures filled with metalliferous matters. They further believe, that fiſſures have been occaſioned by the exſiccation of ſtrata, while theſe were paſſing from a fluid to a ſolid ſtate. Wallerius thinks, that fiſſures have been formed from exſiccation, but that veins were channels made through the ſtrata, while yet ſoft and fluid, by water, or by the more fluid parts of the ſtrata penetrating and forcing a paſſage through the more ſolid parts. He thinks, that theſe fluid parts conveyed thither their metalliferous and ſtony contents, which were there coagulated or concreted. He ſupports his opinion by obſerving, that all the veins of the ſame ſtratum generally run parallel to each other; that they frequently bend in their courſe; that the ſame vein is ſometimes contracted and ſometimes dilated; that veins are frequently terminated by being ſplit or divided into inferior veins; that veins are frequently wider at bottom than at top, whereas fiſſures are always wideſt at top and are very narrow below: all which appearances, he thinks, could not have been produced by exſiccation. From theſe reaſons, fiſſures appear to have had a different, and from the diſjunction and rupture of veins croſſed by fiſſures, they ſeem to have had a later origin than veins. Whether fiſſures could have been produced by the very gradual exſiccation of theſe large maſſes of ſtrongly coherent matter; or whether they have been produced by the ſame violent cauſes, namely, earthquakes, by which the ſtrata in which fiſſures are generally found have been broken and deranged, and by which metalliferous mountains themſelves have been formed, or their ſtrata raiſed above their original level; as ſome authors have, with great probability, conjectured; I do not pretend to determine.

Veins are ſeldom, if ever, found but in mountains. The reaſon of which may not improbably be, that in metalliferous mountains we have acceſs to the more ancient ſtrata of the earth, which in plains are covered with ſo many depoſited, alluvial, and other later ſtrata, that we can ſeldom, if ever, reach the former. That theſe mountains conſiſt of ſtrata which have been originally lower than the upper ſtrata of adjacent plains, appears from an obſervation which has been made, that the ſtrata of mountainous countries dip with more or leſs declivity as they approach the plains, till they gradually ſink under the ſeveral ſtrata of thoſe plains, and are at laſt immerſed beyond the reach of miners. This leading fact in the natural hiſtory of the earth has been obſerved by a ſagacious philoſopher, *Mr. Mitchell*, in his *Conjectures concerning Earthquakes, &c. Philoſ. Tranſ.* 1760.

That the inferior ſtrata of the earth contain large quantities of pyritous, ſulphureous, and metalliferous matters, appears, 1. From the ſubterranean fires in thoſe inferior ſtrata, which produce volcanos, and probably earthquakes (as Mr. Mitchell ingeniouſly conjectures). 2. From the obſervation, that all kinds of mountains are not equally metalliferous; but that veins, eſpecially, are only found in thoſe mountains, which, being compoſed of very ancient ſtrata, are called *primæval*, which form the chains and extenſive ridges on the ſurface of the earth, which direct the courſe of the waters, and which conſiſt of certain ſtrata, the

The gold which is found alone is called *native*, or *virgin gold*. This is generally incrusted, and fixed in different kinds of stones, principally in flints

the thickness of each of which, its generic qualities, and its position relatively to the other strata, are, in different parts of the chain of mountains where that stratum is found, nearly uniform and alike, notwithstanding that the numbers, and the inclinations of the strata composing contiguous mountains, or even different parts of the same mountain, are often very various; and therefore that veins are seldom, if ever, found in the mountains called by authors *diluvial* and *temporary*, which are single, or detached, which consist not of strata uniformly disposed, but of alluvial masses, in which fragments of ores may be sometimes, but veins never, found. Nevertheless, single, and seemingly detached, mountains in small islands have sometimes been found to be metalliferous. But we must observe, that these mountains consist of uniform strata; that islands themselves, especially small islands, may be considered as eminent parts of submarine ranges of mountains; and that the mountains of such islands may be considered as apices or tops only of inferior mountains.

Those mountains are said to be most metalliferous which have a gentle ascent, a moderate height, and a broad basis, the strata of which are nearly horizontal, and not much broken and disjoined. In these mountains, at least, the veins are less interrupted, more extended, and consequently more valuble to miners than the veins in lofty, craggy, irregular, and shattered mountains.

Authors dispute concerning the time in which ores have been formed, some referring it to the creation of the world, or to the first subsequent ages; and others believing, that they have been gradually from all times, and are now daily, formed. From the accretion of ores and of their matrices to their proper rocks, and from the insertion of metalliferous nodules and striæ in the hardest stones, we are inclined to believe, that the matter of these veins and nodules are coeval with the rocks and stones in which they are inveloped. Neverthelesss, we cannot doubt that small quantities, at least, of ores are still daily formed in veins, fissures, and other subterranean cavities. Several well attested instances confirming this opinion are adduced by authors: Cronstedt mentions an incrustation of silver-ore that was found adhering to a thin coat of lamp-black, or of soot, with which the smoke of a torch had soiled a rock in a mine at Koningsberg in Norway; and that this incrustation of silver-ore had been formed by a metalliferous water passing over the rock. Lehman affirms, that he possesses some silver-ore attached to the step of a ladder, found in a mine in Hartz, which had been abandoned two hundred years ago; and that several steps of ladders similarly encrusted had been found. Many other instances are mentioned by authors, of galena, pyrites, silver-ores, and other metalliferous substances, having been found adhering to wood, to fossil-coal, to stalactitical encrustations, to oyster-shells, and other recent substances. From these, and from similar instances which I have seen, I am induced to believe, that not only ochres and fragments of ores may, with other alluvial matters, be now daily deposited, but also that small quantities of mineralised ores are recently formed; although many histories mentioned by Becher, Barba, Henckel, and other authors, of the entire renovation of exhausted veins, and especially those of the growth and vegetation of metals and of ores, appear to be at least doubtful.

Various opinions have been published concerning the formation of mineralised ores. According to some, these ores were formed by congelation of the fluid masses found in mines, called *Guhrs*. *See* Guhr. Other authors believe, that ores have been formed by the condensation of certain mineral, metallic, sulphureous, and arsenical vapors, with which they suppose that mines abound. Some have even affirmed, that they have seen this vapor condense, and become in a few days changed into gold, silver, and other metallic matters: but the existence of such vapors is not ascertained; for the noxious vapors commonly supposed to be sulphureous, arsenical, and metalline, are nothing but the permanently elastic vapors called *inflammable* and *uninflammable fixable airs*. *See* Damps.

Whether the component parts of ores have been once reduced to a state of vapor, and

and quartz. Mr. Cramer ſays, that the yellow brilliant ſpots of the blue ſtone, called *lapis lazuli*, are native gold; but theſe are very ſmall. (c)

Gold is alſo found in fat and muddy earths; and Mr. Cramer affirms, that ſcarcely any ſand can be found which does not contain gold; but he acknowledges, at the ſame time, that the quantity is too ſmall to compenſate for the expence of obtaining it.

Laſtly, the largeſt quantity of native gold is to be found in the ſands of ſome rivers. It is chiefly collected in hollows at the bottom of theſe rivers, and at their ſeveral bendings. The gold is collected in theſe places by a natural operation, ſimilar to that of waſhing of ores.

A conſiderable quantity of gold is in the ſand of ſeveral rivers in France; ſo that perſons who collect it find enough to compenſate their trouble. Mr. Reaumur, in a Memoir that he gave in the year 1718 concerning the Rivers of France which contain gold, enumerates ten of them, namely, the Rhine, the Rhone, the Doux, the Ceze, and the Gardon, the Arriege, the Garonne, two ſtreams which flow into the Arriege, called Ferriet and Benagues; laſtly, the Salat, the ſource of which is in the Pyrenean mountains.

The Ceze is the river which furniſhes the largeſt quantity of gold at certain times. Mr. Reaumur obſerves, that its particles are larger than thoſe of the Rhine and of the Rhone, and ſays, that in ſome days a peaſant will find gold to the value of a piſtole, and in others will ſcarcely find any.

and in that ſtate have been united; or whether theſe parts were conveyed to veins already combined, but in a fluid ſtate; or by what natural proceſs they have been brought together and united, we have not ſufficient data to inveſtigate and determine.

We can indeed by analyſis diſcover what theſe component parts of ores are; and we can even imitate many ores by fuſing together thoſe parts: but, from the regularity of the forms and ſtructures of ores, the union of their component parts muſt have been accompliſhed by a more gradual proceſs; and, although it be difficult to explain how ores could be diſſolved in a watery menſtruum, and afterwards cryſtallized, ſo as to form the regular maſſes which they now conſtitute; yet when we conſider how many ſolutions and decompoſitions are effected by the very ſlow and gradual operations of nature, which cannot be effected by thoſe of art, the conjecture (if, in a ſubject ſo obſcure, and concerning which neither ſufficient facts have been diſcovered, nor is the life of man ſufficiently long to make obſervations and experiments, conjectures may be admitted) ſeems not improbable that ores, and perhaps all other mineral cryſtallized matters, as ſpars, cryſtals, fluors, &c. have been once diſſolved in an aqueous menſtruum, by evaporation of which they have been afterwards concreted and cryſtallized. An inſtance of the formation of ſilver-ore from a metalliferous water has already been quoted from a Memoir in the Swed. Act. by Mr. Cronſtedt. The liquors called *guhrs*, found in mines, are known to contain frequently, beſides metallic matters, alſo calcareous and gypſeous particles. By intervention of theſe earthy matters, may not alſo ſulphur be diſſolved in water, and thus a hepar, the moſt powerful ſolvent of metallic ſubſtances, be formed? If we ſuppoſe ſuch a hepar impregnated with metallic particles to be collected in a ſubterranean cavity, where the water might be exceedingly ſlowly evaporated, till no more remained than was ſufficient for the cryſtallization of the ſolid matters, might not theſe matters then ſeparate and cryſtallize diſtinctly; the earthy ſubſtances firſt concreting, and forming ſpars, fluors, and other matrixes, which would adhere to the ſolid rock, while the ſulphureous, arſenical, and metallic ſubſtances ſhould afterwards concrete together, and compoſe ores which would adhere to the matrixes previouſly formed?

(c) Concerning theſe, *ſee* LAPIS LAZULI.

the

The native gold found in rivers or elsewhere is never perfectly pure, or of twenty-four karats. It always contains a certain quantity of allay, which is generally silver. The gold of our rivers, according to Mr. Reaumur's trials, was found to be from eighteen to twenty-two karats, that of the Ceze being the lowest, and that of the Arriege being the purest. (*d*).

DXI. ORES *of* PLATINA. Platina is very rare, and has been but lately discovered. As, like gold, it cannot be allayed with sulphur or with arsenic, probably no ore properly so called exists of this metal. Accordingly,

(*d*) ORES *of* GOLD. Although gold cannot be directly dissolved by sulphur, yet it probably may be mineralised by the intervention of other metallic matters. Thus, although no proper ore of gold exists, yet it is found in several mineral substances, in which it is always accompanied, as Cramer affirms, with a much larger quantity of silver; to which latter metal that author attributes its mineralised state. The minerals containing gold are blend, cupreous and arsenical pyrites, ore of antimony, cinnabar, white ore of arsenic, vitreous and other silver ores, and the lead-ore called galena.

Gold is more frequently imbedded in quartz than in any other matrix, but it is also found in limestone and in hornblend. Gold mines are in general very precarious, as they do not form regular veins, nor is the gold uniformly distributed through a matrix.

Becher and Cramer think, that no sand is entirely free from gold. The yellow, red, black, and violet-colored ferruginous, are said to contain most gold. Mr. Hellot relates, that in eleven essays of one kind of sand, from a quintal, or 921600 grains, were obtained each time from 848 to 844 grains of noble metal, exclusive of the gold which remained in the scoria; and that of the metal thus obtained two thirds were gold, and the remaining third was silver. He says, that parcels of sand taken up at very small distances from each other contained very unequal proportions of gold.

The gold found in sands is generally less pure than that which is imbedded in a solid matrix. Reaumur says, that a piece of gold, weighing 448 ounces, was shewn to the Royal Academy at Paris, which was found upon essay to have different fineness in different parts of the mass.

Ores and earths containing gold may be essayed by the methods directed for the extraction of gold from large quantities of these auriferous matters (*see* SMELTING *of* ORES): or they may in general be essayed by being fused in a cupel or test, placed under the muffle of an essay-furnace, or in a crucible placed in an air-furnace, with eight or ten times their quantity of lead, if they be fusible; and with a larger quantity of lead, if they be difficultly fusible; and by scorifying the earthy matters, while the lead becomes impregnated with the noble metals. These operations are entirely similar to those employed for the separation of silver from its ores by precipitation with lead; *a detail of which see subjoined under the article* ORES *of* SILVER, *in a Note* [*Processes* I. III. IV. V. VI]. These metals are afterwards to be separated from the lead by cupellation, in the manner directed in the articles, ESSAYS *of the* VALUE *of* SILVER, *and of* GOLD. The gold is then to be separated from the silver by the processes described in the article PARTING.

The quantity of lead to be added to the ore in this essay must be such as renders the scoria very thin, that the whole gold may be imbibed by the lead. Some iron-ores containing gold cannot be reduced into a scoria sufficiently thin with sixteen times their quantity of lead, unless the heat be, at the same time, considerably encreased. When the ore is exceedingly refractory, the scorification ought to be promoted by adding to it four times its quantity of tartar, twice its quantity of nitre, and four times its quantity of litharge. This mixture is to be put in a good essay-crucible, and covered with sea-salt. The crucible is to be set in a forge-hearth, and exposed gradually to heat, till the scoria has acquired sufficient fluidity, and the lead has imbibed the noble metal.

See the methods which have been used for essaying auriferous sands, under the article SMELTING *of* ORES.

in the only mines of platina which we know, namely, the gold mines of Santafe near Carthagena, the platina is found native like the gold, and in its metallic state.

DXII. ORES *of* SILVER. Next to gold, silver is the metal most frequently found in its metallic state, that is, not mineralised by sulphur or by arsenic. This silver, called also *native* or *virgin*, generally affects some regular form, and consists of filaments or vegetations of various figures. Native silver, like gold, is incrusted, or adherent to several kinds of stones. It is generally allayed with some gold: but silver, like all the other metals, is much more frequently found mineralised by sulphur and by arsenic. (*e*)

Three principal proper ores of silver are known, which are very rich, but vere rare. These are;

1. The *vitreous silver ore*. This ore has no determinate figure, and has nearly the color, softness, and fusibility of lead. It is very heavy, and contains three quarters of its weight of pure silver. In this ore the silver is mineralised by sulphur alone. Some expert artists imitate it very well by combining sulphur with silver by fusion in a crucible. (*f*)

2. The *horny* or *corneous silver ore*. This ore is so called from its color and semitransparency, by which it resembles horn or colophony. This ore, being suddenly heated, crackles, as almost all ores do, and melts with a gentle heat. Two-thirds of it are silver, which is mineralised by sulphur and arsenic. This ore is very rare. Wallerius says, after Woodward, that it is found at *Johaun-Georgen-Stadt* in *Saxony*. (*g*)

3. *Red silver ore*, called also *Rosiclare*. Its color is more or less red; it is sometimes crystallized, very heavy, and is fusible like the above-mentioned ores. In this ore the silver is mineralised by arsenic and by sulphur, but chiefly by the former. It also contains a little iron, and furnishes two-thirds of its weight of silver. Its red color may proceed either from the iron it contains, or from the mixture of arsenic and sulphur, or, lastly, from the particular manner in which the arsenic is united with the silver, an example of which we

(*e*) ORES *of* SILVER. *Native silver* is found in form of plates, of fibres, or of grains, or crystallized. It lies generally in quartz, flint, spar, slate, cobalt, and in silver-ores. It is sometimes enveloped in a thin stony crust.

(*f*) The *vitreous ore*, according to Cronstedt, is either in form of plates or of fibres, or is crystallized, or has no determinate figure. It may be imitated by adding about five parts of sulphur to one part of melted silver; in which operation most of the sulphur is consumed: or it may be imitated by exposing a plate of silver red-hot to the fumes of burning sulphur.

(*g*) *Corneous ore* has various colors; white, pearly, brown, yellow, greenish, or reddish. It is foliated and semitransparent. It is somewhat ductile, and fusible with the flame of a candle. When heated, it emits, as Wallerius says, a sulphureous and blue flame, and, according to Cramer, also a very small quantity of an arsenical fume. Wallerius says, that it contains two-thirds of silver, with a considerable quantity of sulphur and a small quantity of arsenic. Lehman thinks, that it is silver united with a little arsenic. But Mr. Cronstedt says, that it is a luna cornea, or silver combined with marine acid; and that it is incapable of being decomposed but by substances which can unite with that acid. This latter opinion seems to be the most probable, as the ore, according to its description, is similar to luna cornea, and as it cannot be imitated by any mixture of sulphur and of arsenic with silver. The blue flame, and the smell slightly arsenical, which are emitted from heated corneous ore, are also observable from every combination of marine acid with a substance containing phlogiston.

 have

have in the red precipitate of silver made by the neutral arsenical salt. *See* ARSENIC *and* SALT (NEUTRAL ARSENICAL). (*h*)

Besides these, many other minerals are called silver ores, but which are only improper ores of silver as they contain a larger quantity of some other metal (*i*).

(*h*) *Red silver ore* is either plated or solid, or crystallized, and frequently semitransparent. Its color is various, from a dark grey to a deep red, according to the proportions of the two mineralising substances. It crackles and breaks in the fire, exhales an arsenical fume, and is readily fused. It is found generally in quartz, spar, crystal, hornblend.

(*i*) Besides the three silver-ores above described, the following ores contain silver mixed with other metals.

1. *Grey silver ore.* This contains copper and silver mineralised by arsenic and sulphur, and generally more of the former than of the latter metal; but as it is valued chiefly for the silver, it has been generally enumerated amongst silver ores.

2. *White silver ore* is an arsenical pyrites containing silver.

3. *Black silver ore* contains sulphur, arsenic, copper, iron, sometimes lead, and about a fourth part of silver, according to Wallerius.

4. *Plumose silver ore* is white or black, striated like plume-alum, or like ore of antimony. It is silver mineralised by sulphur, arsenic, and antimony.

5. *Pech-blend.* In this blend silver, gold, and zinc, are mineralised by sulphur, probably by intervention of iron, by which the gold and zinc are rendered capable of uniting with the sulphur.

6. Silver is frequently found in *galena*; and sometimes in *martial pyrites*; in the *red ore of arsenic*; in various *ores of copper*, *lead*, *tin*, *iron*, and especially *cobalt*; in *blends*; in *yellow* or *red earths*; in *black* and *blue basaltes*; and also in *strata of stones*, which do not appear externally to contain any mineral substance.

7. *Liquid silver ore*, or *guhr of silver*, is a grey or whitish liquid mass which contains, as Wallerius says, either native silver, or some fluid substance capable of producing it. Mr. Cronstedt mentions, in the Swedish Memoirs, a water flowing through a mine in Norway containing silver. Another instance is also mentioned of a silver guhr, in the Act. Erud. Upsal. 1720.

8. Mr. Von Justi pretends, that he has found silver mineralised by an *alkaline substance*; but he has not spoken sufficiently distinctly concerning it, to know whether he means a saline or earthy alkaline matter. Henkel also pretends, that by treating calcareous earth or certain clays with pyrites, silver may be obtained.

Ores of silver may be essayed [*see the article* ESSAY *of* ORES] by the same methods which are employed for the extraction of that metal from large quantities of ores; which methods are different, and suited to the different qualities of the several ores. *See* SMELTING *of* ORES. Or, in general, ores and earths containing silver may be essayed by the following Processes, which are copied from Dr. Mortimer's English edition of *Cramer's Art of Essaying Metals, Part* II. *Process* 1.

PROCESS I.

To precipitate Silver by means of Lead from fusible Ores.

" POUND the ore in a very clean iron-" mortar into fine powder: of this weigh " one docimastical centner or quintal, and " eight of the like centners of granulated " lead.

" Then have at hand the docimastical " test (*see* PLATE I.), which must not as " yet have served to any operation: pour " into it about half of the granulated lead, " and spread it with your finger through " the cavity of it.

" Put upon this lead the pounded ore; " and then cover it quite with the re-" mainder of the granulated lead.

" Put the test thus loaded under the " muffle of an essay-furnace, and in the " hinder part of it: then make your fire, and " encrease it gradually. If you look thro' " the holes of either of the sliders, you will " soon see that the pounded ore will be " raised out of the melted lead, and swim " upon it. A little after, it will grow " clammy, melt, and be thrown towards " the border of the test: then the surface of " the lead will appear in the middle of the " test like a bright disc, and you will see it " smoak and boil: so soon as you see this,

Such are the *blue silver-ore*, which is only a lead-ore containing much silver, and the *grey silver-ore*, which is a copper-ore containing silver.

" it will be proper to diminish the fire a " small matter for a quarter of an hour; so " as that the boiling of the lead may almost " cease. Then again, encrease the fire to " such a degree that all may turn into a " thin fluid, and the lead may be seen, as " before, smoaking and boiling with great " violence. The surface of it will then " diminish by degrees, and be covered over " with a mass of scorias. Finally, have at " hand an iron hook ready heated, where- " with the whole mass must be stirred, espe- " cially towards the border; that in case " any small parcels of the ore not yet dis- " solved should be adherent there, they may " be brought down, taking great care not " to stir any the least thing out of the test.

" Now, if what is adherent to the hook " during the stirring, when you raise it " above the test, melts quickly again, and " the extremity of the hook grown cold is " covered with a thin, smooth, shining crust; " it is a sign that the scorification is perfect; " and it will be the more so as the said crust " adherent to the hook shall be colored " equally on every side: but in case, while " the scorias are stirred, you perceive any " considerable clamminess in them, and " when they adhere in good quantity to the " hook, though red-hot, and are inequally " tinged, and seem dusty or rough with " grains interspersed here and there; it is " a sign that the ore is not entirely turned " into scorias. In this case, you must with " a hammer strike off what is adherent to " the hook, pulverize it, and with a ladle " put it again into the test, without any loss " or mixture of any foreign body, and con- " tinue the fire in the same degree till the " scoria has acquired its perfection, and the " above-mentioned qualities. This once " obtained, take the test with a pair of " tongs out of the fire, and pour the lead, " together with the scoria swimming upon " it, into a cone made hot and rubbed with " tallow. Thus will the first operation " of the process be performed, which does " not commonly indeed last above three " quarters of an hour.

" With a hammer strike the scorias off " from the regulus grown cold, and again " examine whether they have the character- " istics of a perfect scorification; if they " have, you may thence conclude, that the " silver has been precipitated out of the ore " turned to scorias, and received by the " lead.

" When the scorification lasts longer than " we mentioned, the lead at last turns to " scorias or litharge, and the silver remains " at the bottom of the vessel: but the fire " must be moderately supplied, and the " vessels be extremely good, to produce this " effect; for they seldom resist to the strength " of the scorias long enough; so that the " whole scorification may be brought to an " end; which has afterwards this inconve- " niency, that the silver is dissipated by " grains in the small hollows of the corroded " ore, and can hardly be well collected " again, when the ore has but little silver in " it. Nay, there is still more time to be " consumed to obtain the perfect destruction " of the lead, by means of the combined " actions of the fire and air, because the " scorias swimming at the top retard it con- " siderably.

" In this process, the sulphur and the " arsenic of the silver-ore, when the ore is " broken small, and extended widely in a " small quantity, are in part easily dissipated " by the fire, and in part absorbed by the " lead; the lighter part of which, swimming " upon the heavier, becomes very clammy " by means of the sulphur which is in the " ore; but when this is dissipated by the " violence of fire, it turns into glass or " scorias: but when arsenic is predominant " in the ore, the plumbeous part turns im- " mediately into a very penetrating and very " fusible glass, having a dissolving efficacy, " unless the arsenic lies hidden in a white " pyrite or cobalt. For this reason, the " fixed part of the ore, which is no silver, " is dissolved by that glass, melts, and as- " sumes the form of scorias. The unme- " tallic earths and the pure copper or lead- " ores thereto adherent are of this kind. The " silver then remains immutable, and being " freed of these heterogeneous bodies, which " are partly dissipated and partly melted, it " is precipitated and received by the remain-

DXIII. ORES *of* COPPER. Copper is found under ground

" ing regulus of lead. Therefore this pro-" cess is completed by three distinct opera-" tions; viz. 1. By roasting. 2. By scori-" fication. 3. By the melting precipitation " of the silver, which is the result of the two " former operations.

" The ore must be pulverised very fine in " order to encrease the surface, that the dis-" sipation of the volatiles and the dissolution " by litharge may be sooner effected. This " pulverising must then be done before the " ore is weighed, because there is always " some part of the ore adherent to the mor-" tar or iron-plate on which it is made fine; " which part being lost, the operation is not " exact. *Erker* was in the right when he " prescribed eight centners of lead for the " subduing of fusible ores. Nevertheless, " it must be owned that this quantity is " superfluous in some cases. However, as " the fluxibility of the silver-ore depends " from the absence of stones, pyrites, &c. it " is easy to see, that there are an infinite " number of degrees of fluxibility which it " would be needless to determine exactly, " and most commonly very difficult to de-" termine by the bare sight. Besides, a little " more lead does not render the process im-" perfect; on the contrary, if you use too " small a quantity of lead, the scorification " is never completely made. Nay, there " are a great many ores, containing sulphur " and arsenic in plenty, that destroy a con-" siderable quantity of lead: such are the " red silver-ore, and that wherein there is a " great deal of the steel-grained lead ore. If " the fire must be sometimes diminished in " the middle of the process, it is in order " to hinder the too much attenuated litharge, " which is continually generated out of the " lead, from penetrating the pores of the " test, and from corroding it; which is " easily done when the fire is over-strong; " for then the surface of the vessel which is " contiguous to the lead contracts cavities, " or being totally consumed by small holes, " lets the regulus flow out of it. The ves-" sels that are most subject to this inconve-" nience are those in the materials of which " lime, plaster, and chalk are mixed. Nay, " these bodies, which are of their nature re-" fractory, being eroded during their scori-" fication, at the same time, communicate " a great clamminess to the scoria; so that " a great quantity of the mass remains ad-" herent to the test in the form of protube-" rances, when you pour it out; whereby " a great many grains of the regulus are " detained."

PROCESS II.

THE regulus obtained by the process I. contains all the silver of the ore, and the unscorified part of the lead. The silver may be afterwards separated from the lead, and obtained pure by *cupellation*; which process is described under the article of the Dictionary, ESSAY *of the* VALUE *of* SILVER.

PROCESS III.

IF the silver-ore cannot be washed clean, or if it be rendered refractory by a mixture of unmetallic earths and stones, the scorification of these earthy matters frequently cannot be completed by the process I. Cramer therefore directs that such ores shall be treated in the following manner [*Art of Assaying*, *Part* II. *Process* 3].

" Bruise the ore into an impalpable " powder, by grinding in a mortar; to a " docimastical centner of it, add a like " quantity of glass of lead finely pulverised; " for the more exactly these two are mixed " together, the more easily the scorification " afterwards succeeds. Put this mixture, " together with twelve centners of lead, into " the test, according to process I. then put " the test under the muffle.

" Make first under it a strong fire, till the " lead boils very well; when you see it so, " diminish the violence of the heat, as was " directed in the first process; but keep it " thus diminished a little longer: then, " finally, again encrease the fire to such a " degree, till you perceive the signs of a " perfect scorification and fusion. *See the* " *whole Process* I. Now this process lasts a " little longer than the foregoing, and " requires a greater fire towards the end.

" It sometimes happens that a very re-" fractory ore cannot be dissolved by litharge; " and that a mass, which has the clamminess

" of

in three different forms. 1. Native or virgin copper diversely ramified, which

" of pitch, swims upon the regulus and upon " the scorias themselves which are already " subdued in part: when you see this, shut " the vents of the furnace to diminish the " fire; then gently touch this refractory body " with a small iron cold hook, to which it " will immediately stick; take it off softly, " not to lose any thing; pound it into a fine " powder, adding a little glass of lead; and " put it again into the test; then con- " tinue the scorification, till it is brought " to its perfection. But you must always " examine the scoria of your refractory ore, " to see whether there may not be some " grains of regulus dispersed in it; for some- " times the scorias that grow clammy retain " something of the metal; which if you " suspect, pound the scoria into a fine dust, " and thus the grains of metal will appear, " if there are any left; because they can " never be pounded fine. The silver is sepa- " rated from this regulus by coppelling, as " in Process II.

" All earths and stones are refractory in " the fire; for, although some of them melt " naturally in the fire, as those that are " vitrifiable do; nevertheless, all the others, " a very few excepted, melt much more dif- " ficultly than metals, and never become " so thin in the fusion as is required for " the sufficient precipitation of a precious " metal. But litharge itself does not con- " veniently dissolve these refractory matters " by the help of fire alone, unless you add " some mechanical mixture to them; for " the very moment the said litharge pene- " trates through the interstices of the refrac- " tory ore, and begins to dissolve it, a tena- " cious mass is produced, which hardly " admits any farther dilution by the litharge. " You may see it plain, if you make colored " glasses with metallic calxes; if you pour " carelessly upon them a calx that gives a " color, you will never obtain that they may " be equally died on every side, even altho' " you should torture them for whole days " together in a great fire. Nay, glass already " made can never be diluted by only pouring " salts and litharge upon it. Wherefore, " you must use the artifice of glass-makers, " who in the making of the most perfect " glasses, take great care before they put the " species of their ingredients into the fire, to " have a mechanical mixture precede, or at " least accede during the fusion itself; which " is done here by pounding glass of lead " mixt with the ore: but if you think that " your glass of lead is not sufficiently fusible, " you may add to it litharge melted first, and " then pounded into a fine powder.

" As this scorification requires a longer " and a greater fire than the foregoing, and " as a greater quantity of litharge is more- " over requisite to subdue the refractory " scoria; it is easy to see why a much " greater quantity of lead must be used here " than in Process I. and, although less lead " is often sufficient, it is nevertheless proper " always to use the greatest quantity that " can be necessary, lest, for instance, it " should be necessary to try so many times " the lead alone, to make it evident how " much silver the lead when alone leaves in " the coppel. Nor need you fear lest any " thing of the silver be taken away by the " lead, provided the coppels be good, and " the coppelling duly put in execution: for " you can hardly collect a ponderable quan- " tity of silver out of the collected fume of " the lead, which rises during the coppelling, " as well as out of the litharge, that is with- " drawn into the coppel."

PROCESS IV.

IF the ore be rendered refractory by pyrites, Cramer directs, that the silver should be precipitated by lead in the following manner. [*Art of Assaying*, *Part* II. *Proc.* 4.]

" Break your ore into a rough powder, " and put a centner of it into the test: put " upon this another test in the manner of a " tile; put it under the muffle hardly red- " hot: increase the fire by degrees. There " will always be a crackling: which being " ended, take away the upper test; for when " the vessels have been red-hot about one " minute, the ore ceases to split. Leave the " ore under the muffle till the arsenic and " the sulphur are for the most part eva- " porated; which you will know from the " cessation of the visible smoak, of the smell " of garlic, or the acid; then take away the " test, and leave it in a place not too cold, " that it may cool of itself.

" Pour out, without any dissipation, the " roasted

is much more rare than native silver. This native copper is not so ductile as

" roasted ore, and with a knife take away, " what is adherent to the vessel; pound it " to a most subtle powder, and grind it to- " gether with an equal weight of glass of " lead; and, finally, scorify the whole col- " lected ore in the same test wherein the " testing was made, unless it has contracted " chinks, as was described in Process III. "

" *Remarks.* Yellow pyrites-ores contain " a very great quantity of sulphur, even " greater than is necessary to saturate the " metal that lies hidden in them. For which " reason this superfluous sulphur dissipates in " a middling fire; but if it had been mixed " with lead it would have rendered it refrac- " tory, nor could it afterwards be dissipated " from it without a considerable destruction " of the lead. The white arsenical pyrites " turn also a great quantity of lead into " glass, on account of the abundance of the " arsenic they contain. For which reason " these ores must be previously roasted, that " the sulphur and arsenic may be dissipated. " Nor need you fear lest any part of the " silver be carried away with the arsenic; " for when arsenic is separated from any " fixed body, by a certain degree of fire, it " carries nothing of that body away with " it."

PROCESS V.

SILVER may be precipitated from its ore by cupellation only, in the following Process, given by Cramer. [*Art of Assaying*, *Part* II. *Proc.* 9.]

" Pound one centner of ore; roast it in " the manner directed in the last process; " beat it to a most subtle powder; and if it " melts with difficulty on the fire, grind it " together with one centner of litharge, " which is not necessary when the ore melts " easily: then divide the mixture or the " powder of the ore alone into five or six " parts, and wrap up every one of them " severally in such bits of paper as can con- " tain no more than this small portion.

" Put a very large coppel under the " muffle; roast it well first, and then put " into it sixteen centners of lead: when the " lead begins to smoak and boil, put upon it " one of the said portions with the small " paper it was wrapt up in, and diminish " the fire immediately, in the same manner " as if you would make a scorification in a " test, but in a lesser time. The small paper, " which turns presently to ashes, goes off of " itself, and does not sensibly encrease the " mass of the scorias. The ore proceeding " therefrom is cast on the border, and turns " to scorias very soon. Increase the fire again " immediately, and, at the same time, put " another portion of the ore into the coppel, " as was just now said. The same effects " will be produced. Go on in the same " manner, till all the portions are thrown in " and consumed in the lead. Finally, des- " troy the remaining lead with a stronger " fire.

" The silver that was in the ore and in the " lead will remain in the coppel. If you de- " duct from it the bead proceeding from the " lead, you will have the weight of the silver " contained in the ore. If the ore employed " was easy to be melted, all the scoria vanishes; " but if it was refractory or not fusible, all the " scoria does not always go away, but there " remains something of it now and then in " the form of dust. A great many ores and " metals may be tried in this way, except " only such as split and corrode the coppels. " There are likewise some of them which " must be previously prepared, in the same " manner as is required, to render them fit " for going through a scorification. *See the* " *foregoing Processes.*

" *Remarks.* The ore thrown at several " times upon lead boiling in a coppel may be " dissolved without the foregoing scorifica- " tion: but this is very far from having an " equal success with all kinds of ores; for " there are ores and metals which resist very " much to their dissolution by litharge; and " which being on this account thrown on the " border, are not sufficiently dissolved; be- " cause the litharge steals away soon into the " coppel. Nevertheless, there are some others " which vanish entirely by this method, ex- " cept the silver and gold that was contained " in them.

" A previous roasting is necessary, first, " for the reasons mentioned, and then be- " cause the ore thrown upon boiling lead " should not crackle and leap out; for, " having once passed the fire, it bears the " most sudden heat."

PRO-

as copper purified by fusions from the ore (*k*). 2. Copper is found in form of calx, of verdigrease, of precipitates. Such are the minerals called silky copper ores, and several white and green earths. These matters are only copper almost pure and but little mineralised, but which has been corroded, dissolved, precipitated, calcined by saline matters, by the action of the air, of water, and of earths (*l*). 3. Copper is frequently in a truly mineral state, that is,

PROCESS VI.

" *Silver may be precipitated out of the same* " *bodies as were mentioned in the foregoing* " *processes by scorification in a crucible.* " [*Cramer*, *Proc.* xv.]

" THE body out of which you intend to " precipitate silver must be previously pre- " pared for a scorification by pounding and " roasting, as mentioned in the former pro- " cesses. Then in the same manner, and " with the same quantity of lead, put it in- " to a crucible strictly examined, that it " be entire, solid, not speckled with black " spots, like the scoria of iron, especially " at its inferior parts, and capable of con- " taining three times as much. Add besides " glass gall and common salt, both very dry, " and enough, that when the whole is melted, " the salts may swim at top at the height " of about half an inch.

" Put the crucible thus loaded into a " wind-furnace; shut it close with a tile; " put coals round it, but not higher than " the upper border of the crucible. Then " light them with burning coals, and in- " crease the fire till the whole melts very " thin, which will be done by a middling " fire, maintained always equal, and never " greater: leave it thus for about one quarter " of an hour, that the scorification may be " perfectly made. Take off the tile and " stir the mass with an iron wire, and a lit- " tle after pour it out into the mould. When " the regulus is cleaned from scorias, try " it in a test by coppelling it.

" *Remarks.* The scorification of any ore " whatever, or of any body fetched out of " ores, may indeed be made by this ap- " paratus, as well as in a test under a muffle: " but it serves chiefly to the end that a " greater quantity of metal may be melted " from it with profit. For you may put " many common pounds of it at one single " time into the crucible; but then you need " not observe the proportion of lead pre- " scribed in the foregoing process; nay, a " quantity of lead two or three times less " is sufficient, according to the different " qualities of the object. But the mass will " certainly be spilt, unless you chuse a very " good crucible; for there is no vessel " charged with litharge, that can bear a " strong fire having a draught of wind, with- " out giving way through it to the litharge.

" You add glass-gall and common salt, " that they may forward the scorification, " by swimming at top; for the refractory " scoria rejected by the litharge, and ad- " hering between this and the salts, that " swim at top; is soon brought to a flux; " and the precipitation of the silver is " thereby accelerated. They also hinder " in a manner a small burning coal fallen " into the crucible, from setting the litharge " a boiling, which troubles the operation; " for the litharge or glass of lead, especially " that which is made without any addition, " so soon as the phlogiston gets into it, " raises into a foamy mass, consisting of a " multitude of small bubbles very difficult " to be confined, unless the phlogiston be " entirely consumed, and the litharge re- " duced to lead, which sometimes rises " above the border of the vessel."

Native metallic silver may be separated from the stones and earths with which it is intermixed, by *amalgamation with mercury*, which operation is to be performed in the same manner as for the separation of native gold; a detail of which see at the article SMELTING *of* ORES.

The *corneous ore*, if it really be, as Cronstedt says, a luna cornea, ought to be treated in some of the methods directed for the reduction of luna cornea. *See* LUNA CORNEA.

(*k*) COPPER ORES. *Native Copper* is solid; or consisting of friable masses, formed by precipitation of cupreous vitriolic waters, called *cement*, or *ziment copper*; or forming crystallized cubes, or grains, leaves, branches, or filaments.

(*l*) *Calciform ores* are either pure calxes of copper, or are mixed with heterogeneous matters. 1. The *pure* are loose friable ochre,

combined with ſulphur, and with arſenic, with other metallic matters mixed with earths, and enveloped in different matrixes. Theſe are the true copper ores. They have no regular forms except they partake of the nature of pyrites. Their colors are very different, which depend chiefly on the proportion of the mineral ſubſtances compoſing them. Laſtly, in almoſt all of them we may perceive green or blue colors, which always indicate an eroſion or calcination of the copper. Moſt copper ores contain alſo ſome iron or ferruginous earth, to which the ochrey color is to be attributed, which might make us believe them to be ores of iron. Ores which contain much iron are the moſt difficultly fuſible.

Copper-ores have almoſt all a yellow, golden, and ſhining color, by which they are eaſily diſtinguiſhed. Some of them are colored with iriſes, and frequently have ſpots of verdegriſe, by which alſo they are diſtinguiſhable from other ores. (*m*)

Ores of copper may be *eſſayed* in methods ſimilar to thoſe employed for ſmelting of large quantities of ores (*ſee* SMELTING *of* ORES); or they may in general be eſſayed by the following proceſſes.

PROCESS I.

[Extracted from *Cramer's Art of Aſſaying, Proc.* 30.]

" *To reduce and precipitate copper from a pure* " *and fuſible ore in a cloſe veſſel.*"

" MIX one, or, if you have ſmall weights, " two docimaſtical centners of ore beat ex" tremely fine, with ſix centners of the black " flux; and having put them into a crucible " or pot, cover them one inch high with " common ſalt, and preſs them down with " your finger: but let the capacity of the " veſſel be ſuch, that it may be only half " full; ſhut the veſſel cloſe; put it into " the furnace; heap coals upon it ſo that " it may be covered over with them a few " inches high; govern the fire in ſuch a " manner, that it may firſt grow ſlightly " red-hot. Soon after you will hear your " common ſalt crackle; and then there will " be a gentle hiſſing noiſe. So long as this " laſts, keep the ſame degree of fire till it " is quite over. Then encreaſe ſuddenly " the fire, either with the funnel and cover " put upon the furnace, or with a pair of " bellows applied to the hole of the bot" tom part, that the veſſel may grow very " red-hot. Thus you will reduce and pre" cipitate your copper in about a quarter

of

ochre, called *cæruleum montanum*, mountain blue, and *viride montanum*, mountain-green; and the *red indurated calx*, called improperly *glaſs copper ore*. 2. *Mixed* calciform ores are thoſe in which the calx of copper is mixed; with *calcareous earth*, forming a mountain blue; with *iron*, forming a black calx; with *gypſum*, an indurated green ore, called *malachites*; and with *quartz*, a red ore.

(*m*) Copper is *mineraliſed*, 1. By *ſulphur*, forming the *grey copper ore*, improperly called *vitreous* (minera cupri vitrea Wallerii). 2. By *ſulphurated iron*, forming the *hepatic copper ore* (minera cupri hepatica Wallerii) of a brown yellow color. It is a kind of cupreous pyrites, and is called by Cronſtedt minera cupri pyritacea. Sometimes it is of a blackiſh grey color, and is then called *pyrites cupri griſeus* (minera cupri griſea Wallerii); ſometimes of a reddiſh yellow, and tarniſhed with blue iriſes on its ſurface, when it is called *minera cupri lazurea*; when of a yellowiſh-green color, it is the *pyrites cupri flavo-virideſcens* (cuprum ſulphure & ferro mineraliſatum Wallerii); and when of a pale-yellow color, it is the *pyrites cupri pallidè flavus*. Moſt of the above pyritaceous ores contain alſo ſome arſenic, but their ſulphur is predominant. 3. *Copper mineraliſed by ſulphur, iron, and arſenic. White copper-ore* (Minera cupri alba Wall.). This ore contains alſo ſome ſilver. 4. *Copper diſſolved by vitriolic acid. Native blue vitriol.* 5. *Copper united with bitumens. Copper-coal-ore.* This is a pitcoal from the aſhes of which copper is obtainable. 6. Copper is alſo found in the mineral called *kupfer-nickel.*

Many copper ores are also rich in silver. Such is that called the white copper ore, the color of which is rather occasioned by arsenic than by silver, al-

"of an hour; then take out the vessel, and "strike with a few blows the pavement "upon which you put it, that all the small "grains of copper may be collected in one "mass.

"Break the vessel, when grown cold, in "two, from top to bottom, as nearly as "you can: if the whole process has been "well performed, you will find a solid, "perfectly yellow and malleable regulus "adhering to the bottom of the vessel, with "scorias remaining at top of a brown "color, solid, hard, and shining, from "which the regulus must be separated with "several gentle blows of a hammer; this "done, weigh it, after having wiped off "all the filthiness.

"A soft dusty and very black scoria is a "sign of a fire not sufficiently strong. Small "neat grains of copper reduced but not pre-"cipitated, and adhering still to scorias, "especially not very far from the bottom, "and an unequal and ramificated regulus, "are signs of the same thing. A solid, "hard, shining, red-colored scoria, espe-"cially about the regulus, or even the re-"gulus itself when covered with a like "small crust, are signs of an excess in the "degree and duration of the fire.

"*Remarks*. All the ores which are easily "melted in the fire are not the objects of "this process; for they must also be very "pure. Such are the vitreous copper ores." [Mr. Cramer means, I presume, the red calciform ore called improperly *glass ore*, and not the *minera cupri vitrea* of Wallerius, which being composed of copper mineralised by sulphur, could not be treated properly by this process, in which no previous roasting is required. The sulphur of this ore would with the alkali of the black flux form a hepar, from which the metal would not precipitate.] "but "especially the green and azure-colored "ores, and the cæruleum & viride monta-"num, which are not very different from "them. But if there is a great quantity "of arsenic, sulphur, or of the ore of "another metal and semi-metal joined to "the ore of copper, then you will never "obtain a malleable regulus of pure copper, "tho' ores are not always rendered refractory "by the presence of these."

PROCESS II.

[*Cramer Pr.* xxxvii.]

"*To reduce and precipitate copper out of ores "rendered refractory by earth and stones that "cannot be washed off.*

"BEAT your ore into a most subtil pow-"der, of which weigh one or two centners, and "mix as much sandiver to them. This "done, add four times as much of the black "flux with respect to the ore; for by this "means, the sterile terrestrial parts are better "disposed to a scorification, and the re-"ducing and precipitating flux may act "more freely upon the metallic particles "freed from all their incumbrances.

"As for the rest, make the apparatus as "in last process: but you must make the "fire a little stronger for about half an hour "together. When the vessel is grown cold "and broken, examine the scorias, whe-"ther they are as they ought to be. The "regulus will be as fine and ductile as the "foregoing.

"*Remarks*. As these copper-ores hardly "conceal any sulphur and arsenic in them, "the roasting would be of no effect, and "much copper would be lost. For no me-"tallic calx, except those of gold and silver, "improperly so called, can be roasted, with-"out you find a part of the metal lost after "the reduction."

PROCESS III.

"*To precipitate copper out of an ore* * *that con-"tains iron.* [*Cramer Proc.* xxxviii.]

"DO all according to last process. But "you will find after the vessel is broken, a "regulus upon no account so fine, but less "ductile, wherein the genuine color of the "copper does not perfectly appear, and "which must be further purified.

"*Remarks.*

* Mr. Cramer still means the calciform ores only, and not the mineralised ores of copper.

though it contains so much silver as to be enumerated by several mineralogists amongst silver ores.

" *Remarks*. The fire used in this operation " is not so strong that the iron should turn " to a regulus. But as copper is the men- " struum of iron, which is of itself very re- " fractory in the fire; for this reason, while " the ore and the flux are most intimately " mixt and confounded by trituration, the " greatest part of the iron being dissolved by " the copper, turns into a regulus along " with it."

PROCESS IV.

[*Cramer Proc.* xxxix.]

" *The roasting of a pyritose, sulphureous, arse- nical, semi-metallic copper ore.*

" BREAK two docimastical centners of " the ore to a coarse powder, put them into a " test covered with a tile, and place them " under the muffle of a docimastical furnace. " But the fire must be so gentle, that the muf- " fle may be but faintly red-hot. When the " ore has decrepitated, open the test, and " continue the fire for a few minutes; then " increase it by degrees, that you may see " the ore perpetually smoaking a little: in " the mean time, it is also proper now and " then to stir it up with an iron hook. " The shining particles will assume a dark " red or blackish color. This done, take " out the test, that it may grow cold. If " the small grains are not melted, nor " strongly adherent to each other, hitherto " all will be well; but if they run again " into one single cake, the process must be " made again with another portion of the " ore, in a more gentle fire.

" When the ore is grown cold, beat it " to a powder somewhat finer, and roast it " by the same method as before; then take " it out, and if the powder is not melted " yet, beat it again to a most subtil powder; " in this you are to take care that nothing be " lost.

" Roast the powder in a fire somewhat " stronger, but for a few minutes only. If you " do not then find the ore any way inclined " to melt, add a little tallow, and burn it " away under the muffle, and do the same " another time again, till the fire being very " bright, you no longer perceive any sul- " phureous, arsenical, unpleasant smell, or " any smoak; and there remains nothing " but a thin, soft powder, of a dark red, or " blackish color.

" *Remarks*. Every pyrites contains iron, " with an unmetallic earth: to which sul- " phur, or arsenic, and most commonly " both always join. Besides, there is cop- " per in many pyrites; but sometimes more, " and sometimes less: some of them are alto- " gether destitute of copper; therefore, so " much as pyrites differ with regard to the " proportion of their constituent particles, so " much do they differ as to their disposition " in the fire. For instance, the more cop- " per there is in pyrites, the more it inclines " to colliquation. The more sulphur and " arsenic it has in it, the more quickly the " melting of it will be procured, and the " reverse: the more iron and unmetallic " earth it contains, the more it proves re- " fractory in the fire. Now if such pyrites " melt in the roasting; as happens to some " of them, if they grow but red-hot; the " sulphur and arsenic that lies hidden there- " in are so strictly united with the fixed " part, that you would in vain attempt to " dissipate them. Nay, in this case, when " it is reduced again into a powder, it re- " quires a much greater time and accuracy " in the regimen of the fire to perform the " operation. For this reason, it is much " better to repeat it with new pyrites. But " you can roast no more than the double " quantity at once of the ore you have " a mind to employ in the foregoing ex- " periment; to the end that, the precipita- " tion by fusion not succeeding, there may " remain still another portion entire; lest " you should be obliged to repeat a tedious " roasting. If you see the signs of a ferreous " refractory pyrites, the operation must be " performed with a greater fire, and much " more quickly. However, take care not to " do it with too violent a fire; for a great " deal of copper is consumed not only " by the arsenic, but also by the sulphur; " and this happens even in vessels shut very " close, when the sulphur is expelled by " a fire not quite so strong; which a re- " iterated and milder sublimation of the sul-

" phur

Lastly, the pyrites of a golden-yellow color which contains copper and sulphur, and the white pyrites which contains copper and arsenic, are considered

" phur in a vessel both very clean and well " closed, will clearly shew.

" When the greatest part of the sulphur " and the arsenic is dissipated, by such causes " as promote colliquation you may make " a stronger fire: but then it is proper to " add a little of some fat body; for this dissolves mineral sulphur; it changes the " mixture of it in some part, which, for instance, consists in a certain proportion of " acid and phlogiston, and at the same time " hinders the metallic earth from being reduced into copper, by being burnt to an " excess. From these effects the reason is " plain, why assayers produce less metals in " the trying of veins of copper, lead, and " tin, than skilful smelters do in large " operations. For the former perform the " roasting under a muffle, with a clear fire, " and without an oily reducing menstruum; " whereas the latter perform it in the middle " of charcoal or of wood, which perpetually " emit a reductive phlogiston.

" The darker and blacker the powder of " the roasted ore appears, the more copper " you may expect from it. But the redder " it looks, the less copper and the more iron " it affords; for roasted copper dissolved by " sulphur or the acid of it is very black, and " iron, on the contrary, very red.

" It is easy to conceive, that there is as " great a difference between the several " kinds of that metal called black copper, " as there is between the pyritose and other " copper-ores, accidentally mixed with other " metallic and semi-metallic bodies. For all " the metals, the ores of which are intermixed " with the copper-ores, being reduced, are precipitated together with the copper; which " is brought about by means of the black flux. " Wherefore iron, lead, tin, the reguline " part of antimony, bismuth, most commonly are mixed with black copper in a multitude of different proportions. Nay it is " self-evident, that gold and silver, which are " dissolvable by all these matters, are collected in such a regulus, when they have " been first hidden in the ore. Besides, " sulphur and arsenic are not always altogether absent. For they can hardly be " expelled so perfectly by the many preceding roastings, but there remain some " vestiges of them, which are not dissipated " by a sudden melting, especially in a close " vessel, wherein the flux swimming at top " hinders the action of the air. Nay arsenic is rather fixed by the black flux, and " assumes a reguline semi-metallic form, " while it is at the same time preserved from " dissipating by the copper.

PROCESS V.

[*Cramer Pr.* xl.]

" *The precipitation of copper out of roasted ore* " *of the last process.*

" DIVIDE the roasted ore into two parts: " each of them shall go for a centner: add to " it the same weight of sandiver, and four " times as much of the black flux, and mix " them well together. As for the rest, do all " according to the process I.: The precipitated regulus will be half malleable, " sometimes quite brittle, now and then " pretty much like pure copper in its " color, but sometimes whitish, and even " blackish. Whence it is most commonly " called *black copper*, though it is not always " of so dark a dye.

PROCESS VI.

[*Cramer*, *Proc.* xliv.]

" *To reduce black copper into pure copper by* " *scorification.*

" SEPARATE a specimen of your black " copper, of the weight of two small docimastical centners at least; and do it in the " same manner, and with the same precautions, as if you would detect a quantity of silver in black copper.

" Then with lute and coal-dust make a " bed in the cavity of a test moistened: " when this bed is dry, put it under the " muffle of the docimastical furnace, in the " open orifice of which there must be bright " burning coals, wherewith the test must " likewise be surrounded on all parts. When

as copper ores by several chemists and naturalists. *See* PYRITES. Henckel and Cramer remark, that no proper ore of copper is known which does not contain a considerable quantity of arsenic.

DXIV. ORES *of* LEAD. Lead is seldom found native and malleable. Neither is it found in form of calx or precipitate, as copper is,

" the whole is perfectly red-hot, put your " copper into the fire, alone, if it contains " lead; but if it is altogether destitute of " it, add a small quantity of glass of lead, " and with a pair of hand-bellows increase " the fire, that the whole may melt with " all speed: this done, let the fire be made " a little less violent, and such as will suf- " fice to keep the metallic mass well melted; " and not much greater. The melted mass " will boil, and scorias will be produced, " that will gather at the circumference. " All the heterogeneous matters being at " last partly dissipated, and partly turned to " scorias, the surface of the pure melted " copper will appear. So soon as you see it, " take the pot out of the fire, and extinguish " it in water: then examine it in a ballance, " and if lead has been at first mixt with " your black-copper, add to the regulus re- " maining of the pure copper, one fifteenth " part of its weight which the copper has " lost by means of the lead, then break it " with a vice; and thus you will be able " to judge by its color and malleability, and " by the surface of it after it is broken, " whether the purifying of it has been well " performed, or no. But whatever caution " you may use in the performing of this pro- " cess, the product will nevertheless be al- " ways less in proportion than what you " can get by a greater operation, provided " the copper be well purified in the small " trial.

" *Remarks*. This is the last purifying " of copper, whereby the separation of the " heterogeneous bodies begun in the fore- " going process is completed as perfectly " as it possibly can be. For, except gold " and silver, all the other metals and semi- " metals are partly dissipated and partly " burnt, together with the sulphur and " arsenic. For in the fusion they either " turn of themselves to scoria or fumes, or " this is performed by means of iron, which " chiefly absorbs semi-metals, sulphur and " arsenic, and the destruction of it is at the " same time accelerated by them. Thus " the copper is precipitated out of them pure; " for it is self-evident, that the unmetallic " earth is expelled, the copper being re- " duced from a vitrescent terrestrial to a me- " tallic state; and the arsenic being dissipated, " by means of which the said earth has been " joined to the coarser regulus's of the first " fusion. But there is at the same time " a good quantity of the copper that gets " into the scorias: however, a great part " of it may be reduced out of them by re- " peating the fusion.

" The fire in this process must be applied " with all imaginable speed, to make it soon " run: for if you neglect this, much of " your copper is burnt: because copper that " is only red-hot, cleaves much sooner, and " in much greater quantity, into half scorified " scales, than it is diminished in the same " time when melted. However, too im- " petuous a fire, and one much greater than " is necessary for the fusion of it, destroys a " much greater quantity of it, than a fire " sufficient only to put it in fusion would " do. For this reason, when the purifying " is finished, the body melted must be ex- " tinguished in water together with the " vessel, lest being already grown hard, it " should still remain hot for a while; which " must be done very carefully to prevent dan- " gerous explosions.

" The scoria of the above process fre- " quently contains copper. To extract " which, let two or three docimastical cent- " ners of the scoria, if it be charged with " sulphur, be beat to a subtil powder, and " mix it, either alone, or, if its refractory " nature requires it, with some very fusible, " common, pounded glass without a re- " ducing saline flux, and melt it in a close " vessel, and in a fire having a draught of " air; by which you will obtain a regulus.

" But when the scoria has little or no sul- " phur at all in it, take one centner of it, " and with the black flux, manage it as " you do the fusible copper ore: [Process I.] " by which you will have a pure regulus."

PRO-

because it is much less liable to lose its phlogiston by the action of air and water: therefore almost all lead is found naturally mineralised.

PROCESS VII.

[The following Process is translated from Mr. Gellert's *Elements of Essaying*, and describes a new method of essaying ores, concerning which, see a note (*n*) subjoined to the article of this Dictionary ESSAY *of* ORES.]

To essay Copper-ores.

ROAST a quintal of ore [in the manner described in Process IV.]; add to it an equal quantity of borax, half a quintal of fusible glass, and a quarter of a quintal of pitch: put the mixture in a crucible, the inner surface of which has been previously rubbed with a fluid paste of charcoal-dust and water: cover the whole with pounded glass mixed with a little borax, or with decrepitated sea-salt: put a lid on the crucible, which you will place in an air-furnace, or in a blast-furnace: when the fire shall have extended to the bottom of the coals, let it be excited briskly during half an hour, that the crucible may be of a brisk red color: then withdraw the crucible; and when it is cold, break it: observe if the scoria be well made: separate the regulus, which ought to be semiductile; and weigh it. This regulus is *black copper*, which must be purified, as in Pr. VI.

If the ore be very poor, and inveloped in much earthy and stony matters, to a quintal of it, a quintal and a half of borax, a quarter of a quintal of pitch, and ten pounds of calx of lead or minium, must be added. The calx of lead will be revived, and will unite with the scattered particles of the copper, and together with these will fall to the bottom of the crucible, forming a compound regulus. When the ores of copper are very rich, half a quintal of borax and a quarter of a quintal of glass will be sufficient for the reduction. If the ore is charged with much antimony, a half or three quarters of a quintal of clean iron filings may be added; otherwise the large quantity of antimony might destroy the copper, especially if the ore contained no lead. If iron be contained in copper-ore, as in pyrites, some pounds of antimony, or of its regulus, may be added in the essay; as these substances more readily unite with iron than with copper, and therefore disengage the latter metal from the former.

PROCESS VIII.

To essay Ores of Copper by humid Solution.

SOME pyrites and ores contain so small a quantity of copper, that it cannot be separated by the above processes, but is destroyed by the repeated roastings and fusions. These, and indeed any copper-ores, may be essayed by humid solution, or by menstruums.

1. By roasting a sulphureous ore, the sulphur is burnt or decomposed, its phlogiston, with part of the acid evaporating, while the remaining part of the acid combines with the metals, especially with the copper and the iron contained in the ore. Accordingly, from an ore thus roasted, a vitriolic solution may be obtained by lixiviation with warm water, especially if the ore has been exposed, during a few days after it has been roasted, to a moist air; as the water thus gradually applied better unites with the combination of the metallic calxes with the concentrated vitriolic acid of the sulphur: but all the copper is not thus reduced by one operation to a vitriol. More sulphur must therefore be combined with the residuous ore by fusion, and must be again burnt off; that the remaining part of the copper may be attacked by some of the acid of the sulphur. By repeating this operation, almost all the copper and iron will be reduced to a vitriolic lixivium, from which the copper may be separated and precipitated by adding clean pieces of iron.

2. Copper-ores may be more easily essayed by humid solution, in the following manner:

Roast the mineralised ores in the manner directed in Process IV. and pulverise them. If the ores be calciform, they do not require a previous roasting. Put this powder into a matrass capable of containing ten times the quantity of the ore: pour upon the ore some water: set the matrass in a sand-bath, that the

Lead is generally mineralised by sulphur. Its ores have a dark white, but a shining metallic color. These ores, although they form irregular masses, are internally regularly disposed, and seem to be composed of cubes of different sizes applied to each other, but not adherent. These ores are generally distinguished by the name *Galena*. They commonly contain about three quarters of lead and a quarter of sulphur. They are accordingly heavy and fusible, although much less so than pure lead.

Most lead-ores contain silver, none but those of Willach in Carinthia are known to be quite free from it: some of them contain so much of it, that they are considered as improper ores of silver. The smaller the cubes of galena are, the larger quantity of silver has been remarked to be generally contained. *(n)*

the water may boil: pour off the lixivium: add to the residuous ore more water with some vitriolic or marine acid: digest as before in the sand-bath, and add this lixivium to the former: repeat this operation, till you find that the acid liquor dissolves no more metal.

By adding clean plates of iron, you may precipitate the copper, which ought then to be collected, fused with a little borax and charcoal dust, and weighed.

We may remark, that although copper is not soluble by a dilute vitriolic acid, yet the calx of it obtained by roasting the ore, and also the calciform ores, are readily soluble in that acid.

3. Stahl advises to essay copper-ores by boiling them, after they have been roasted and powdered, in water, together with tartar and common salt, or with alum and common salt: but I have not found this method so effectual as the preceding (2).

(n) Lead-Ores. Cronstedt doubts whether any native lead has been found. Linnæus says, he has seen what externally appeared to be such. The Author of the Dictionary is mistaken when he says, that no calx of lead is found. As lead unites strongly with vitriolic acid, we might expect to meet ochres of this metal as well as of copper. Accordingly, we find some *calciform ores* of lead. 1. A pure calx of lead, in form of a friable ochre, *cerussa nativa*, found on the surface of galena; or it is indurated with a radiated or fibrous texture, of a white or yellowish-green color, and resembling spar; it is called *spatum plumbi*, *sparry lead-ore*, and *lead-spar*. 2. A calx of lead is found mixed with calx of arsenic, forming the ore called *arsenicated lead-spar*. Sometimes also that calx is mixed with calcareous earth.

Lead is mineralised, 1. With *sulphur*; such are the several kinds of steel-grained and tessclated *galenas*, which also contain generally some silver. 2. With *sulphurated iron and silver*. It is fine-grained or tessclated, and is distinguishable from the former by yielding a black slag when scorified, whereas the former yields a yellow slag. 3. With *sulphurated antimony and silver*. *Plumbum stibiatum Linnæi*. Its color is similar to that of galena, and its texture is striated. 4. With *sulphur and arsenic*. This ore is soft, almost malleable, like lead. From this ore lead may be melted by the flame of a candle.

Lead-ores may be essayed by means of the black flux, in the manner directed by Mr. Cramer, and described in the Dictionary at the article Essay *of* Ores; or by the following process of Mr. Gellert.

Mix a quintal of roasted lead-ore with a quintal of calcined borax, half a quintal of glass finely pulverised, a quarter of a quintal of pitch, and as much of clean iron-filings: put this mixture into a crucible wetted with charcoal-dust and water: place the crucible before the nozzle of the bellows of a forge, and when it is red, raise the fire during fifteen or twenty minutes; then withdraw the crucible, and break it when cold.

Some very fusible ores, such as the galena of Derbyshire, may be essayed, as large quantities of it are smelted, without previous roasting, and without addition, merely by fusion during a certain time. For this purpose nothing more is requisite than to keep the ore melted in a crucible with a moderate heat, till all the sulphur is destroyed, and the metal be collected. To prevent the destruction of any part of the metal after it is separated from the sulphur, some charcoal dust

may

DXV. TIN-ORES. Tin is very ſeldom found pure, but almoſt always mineraliſed, and chiefly by arſenic.

The richeſt ore of arſenic is of an irregular form, of a black or tarniſhed color, and almoſt the heavieſt of all ores. The cauſe of this extraordinary weight is, that it contains much more arſenic than ſulphur, whereas moſt ores contain more ſulphur than arſenic.

The moſt common tin-ore is of the color of ruſt, which proceeds from a quantity of iron, or of iron-ore mixed with it. The tin-ores of Saxony and Bohemia appear to be all of this kind.

One kind of tin-ore is ſemi-tranſparent and like ſpar. Laſtly, ſeveral kinds of garnets are enumerated by mineralogiſts amongſt tin-ores, becauſe they actually contain tin.

The county of Cornwall, in England, is very rich in tin-ores, and the tin contained in them is very pure. From tin-mines in the Eaſt-Indies tin is brought, called *Malacca tin*. No mines of tin have been diſcovered in France; only in Bretagne garnets are found which contain ſome tin. (o)

DXVI. ORES *of* IRON. No iron is found in its metallic ſtate, although ſeveral ſands and earths have the appearance of iron, and are even attractable by a magnet.

may be thrown over the ore, when put into the crucible: but if the galena be mixed with pyrites, eſpecially arſenical pyrites, it requires much roaſting and ſaline fluxes.

(o) TIN-ORES. *Native tin* is ſaid to have been found in Saxony and Malacca. Its ores are all of the calciform kind, excepting *black-lead*, which appears to be tin *mineraliſed by ſulphur and iron*. *See* MOLYBDENA.

The *calciform ores* of tin are, 1. *Tin-ſtone*, which is of a blackiſh-brown color, and of no determinate figure; and *tin-grains*, or *cryſtals of tin*, which reſemble garnets, and are of a ſpherical or polygonal figure, which they have probably acquired by the attrition of their angles. The tin-ſtone ſeems to conſiſt of attrited tin-grains. This ore is calx of tin united with calx of arſenic, and frequently with calx of iron. 2. *Garnets* are ſaid to contain calx of tin united with calx of iron. 3. *Mangeneſe* is ſaid alſo to contain tin. *See* MANGANESE.

Ores of tin may be eſſayed in the ſame manner, according to Cramer, as he directed for the eſſay of lead-ores. *See* ESSAY *of* ORES. He further makes upon this eſſay the following remarks.

1. Tin-ore, on account of its greater gravity, admits better of being ſeparated, by elutriation or waſhing, from earths, ſtones and lighter ores. 2. A moſt exact ſeparation of earths and ſtones ought to be made, becauſe the ſcorification of theſe by fluxes requires ſuch a heat as would deſtroy the reduced tin. 3. The iron ought to be ſeparated by a magnet. 4. By a previous roaſting, the arſenic is diſſipated, which would otherwiſe carry off a great deal of tin along with it in a melting heat, would change another part of it into aſhes, and would vitiate the remaining tin. 5. The eſſay of tin is very precarious and uncertain; becauſe tin once reduced is eaſily deſtructible by the fire, and by the ſaline fluxes requiſite for the reduction.

Mr. Gellert directs, that ores of tin ſhould be eſſayed in the following manner:

Mix a quintal of tin-ore, waſhed, pulveriſed, and twice roaſted, with half a quintal of calcined borax, and half a quintal of pulveriſed pitch: theſe are to be put into a crucible moiſtened with charcoal-duſt and water, and the crucible placed in an air-furnace: after the pitch is burnt, give a violent fire during a quarter of an hour; and then withdraw your crucible. If the ore be not very well waſhed from the earthy matters, as it ought to be, a larger quantity of borax is requiſite, with ſome powdered glaſs, by which the too quick fuſion of the borax is retarded, and the precipitation of the earthy matters is prevented. If the ore contains iron, to the above mixture may be added ſome alkaline ſalt.

Neither is iron generally mineralised so distinctly as other metals are, unless in pyrites and ores of other metals.

Most of the minerals called iron-ores have an earthy, rusty, yellowish or brownish appearance, which proceeds from the facility with which the true iron-ores are decomposed.

Iron is the most common and most abundant of all metals. In Europe, at least, we cannot find an earth, a sand, a chalk, a clay, a vitrifiable or calcinable stone, or even the ashes of any substance, which do not contain an earth convertible into iron. All earths and stones which are naturally yellow or red, and all those which acquire these colors by calcination, receive them from the ferruginous earth mixed with them. The yellow and red ochres consist almost solely of this earth: the black and heavy sands are generally very ferruginous.

One of the richest iron-ores is a heavy stone, the surface of which, when newly broken, is red and bluish, and is exceedingly hard. A quintal of this ore furnishes from sixty to eighty pounds of the best iron by a single fusion, according to Mr. Cramer.

The iron-ore most commonly found is a stone of the color of rust, of an intermediate weight betwixt those of ores in general and of unmetallic stones. This ore has no determinate form, and easily furnishes an iron of good quality.

Blood-stone or hematites, sanguine or red-chalk, and emery, are iron-ores; some of which, for instance, blood-stone, are almost all iron. Most of these substances require but a slight calcination to be rendered very attractable by a magnet, and soluble in aqua fortis: but the iron obtained from them is of a bad quality, and they are therefore neglected. Iron from the hematites is very brittle; that obtained from ochres is red-short. All these iron-ores are so refractory, that they can scarcely be fused.

Iron-ores are very various in their form; or rather they have no determinate form. Sometimes they are earths, sometimes stones, sometimes grains. Accordingly, those naturalists who attend only to the external form of things in classing and subdividing minerals, have been obliged to multiply the names of iron-ores: hence they are called *iron-ores in form of pease, of beans, of coriander seeds, of pepper-corns, of cinnamon,* &c. which Mr. Cramer treats s ridiculous trifles. (*p*)

(*p*) Ores *of* Iron. I. Malleable *native iron* is mentioned by Wallerius, Linnæus, and Cartheuser. II. The *calciform ores* of iron are pure, or mixed. The *pure* calciform ores are, 1. Friable, as the *martial ochre*, which is either in powder, or concreted, as the *bog-ore*; or, 2. they are indurated, *Hematites. See* Hematites. The *mixed* calciform ores consist of the calx of iron mixed with heterogeneous substances: 1. With *calcareous earth*; forming the *white spathose* iron ore. 2. With *siliceous earth*, forming *martial jasper*. 3. With *garnet-earth*, forming *garnets* and *basaltes*. 4. With *argillaceous earths*, forming *boles*. 5. With *micaceous earth*, forming *colored micas*. 6. With *manganese*. *See* Manganese. 7. With an *unknown earth*, which hardens like cement in water; *Terras*. This is chiefly found in the neighbourhood of volcanos. III. Iron is *mineralised*, 1. With *sulphur*, forming *martial pyrites*; *black iron-ore*, which is magnetic, the quantity of sulphur being very small; the *load-stone*. With *arsenic*; *white pyrites*. 3. With *sulphur and arsenic*; the *arsenical pyrites*. 4. With *vitriolic acid*; *native martial vitriol*. 5. With *phlogiston*; *martial coal-ore*. 6. With other sulphurated and arsenicated metals.

Ores of iron may be essayed by the following Processes.

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DXVII. ORES *of* MERCURY. Mercury is ſometimes found pure, fluid, and in its proper metallic ſtate, only mixed with earths and ſtones. Such are the ores of mercury found near Montpellier, in Tuſcany, and in other places.

PROCESS I.

[CRAMER's *Art of Eſſaying, Proceſs* 54.]

To reduce a precipitate Iron out of its Ore in a cloſe Veſſel.

"ROAST for a few minutes in a teſt "under a muffle, and with a pretty ſtrong "fire, two centners of the ſmall weight of "your iron ore groſsly pulveriſed; that the "volatiles may be diſſipated in part, and the "ore itſelf be ſoftened in caſe it ſhould be "too hard. When it is grown cold, beat "it extremely fine, and roaſt it a ſecond "time, as you do the copper-ore, but in a "much ſtronger fire, till it no longer emits "any ſmell; then let it grow cold again. "Compoſe a flux of three parts of the white "flux, with one part of fuſible pulveriſed "glaſs, or of the like ſterile unſulphureous "ſcorias, and add ſandiver and coal-duſt, of "each one half-part; add of this flux three "times the quantity of your roaſted ore, "and mix the whole very well together; "then chuſe a very good crucible, well "rubbed with lute within, to ſtop the pores "which may be here and there unſeen; put "into it the ore mixed with the flux; cover "it over with common ſalt; and ſhut it cloſe "with a tile and with lute applied to the "points.

"Put the wind-furnace upon its bottom "part, having a bed made of coal-duſt. [*See* "*Plate* III.] Introduce beſides into the fur-"nace a ſmall grate ſupported on its iron "bars, and a ſtone upon it, whereon the "crucible may ſtand as on a ſupport: ſur-"round the whole with hard coals, not "very large, and light them at top; when "the veſſel begins to grow red, which is "indicated by the common ſalt's ceaſing to "crackle, ſtop with groſs lute the holes of "the bottom part, except that in which the "nozzle of the bellows is received: blow "the fire, and excite it with great force, "adding now and then freſh fuel, that the "veſſel may never be naked at top: having "thus continued your fire in its full ſtrength "for three quarters of an hour, or for a "whole hour, take next the veſſel out of it, "and ſtrike ſeveral times the pavement upon "which it is ſet, that the ſmall grains of "iron which happen to be diſperſed may "be collected into a regulus, which you "will find after having broken the veſſel.

"When the regulus is weighed, try its "malleability; then make it red-hot; and "when ſo, ſtrike it with a hammer: if it "bears the ſtrokes of a hammer, both when "red-hot and when cold, and extends a "little, you may pronounce your iron very "good: but if, when either hot or cold, it "proves brittle, you may judge it to be not "quite pure, but ſtill in a ſemi-mineral "condition.

"*Remarks*. The arſenic, but eſpecially "the ſulphur, muſt be diſſipated by roaſting; "for the former renders the iron brittle, and "the latter not only does the ſame, but, be-"ing managed in a cloſe veſſel, with a ſaline "alkaline flux, turns to liver of ſulphur; to "the action of which iron yielding in every "reſpect, it can upon no account be preci-"pitated; and if not the whole, a great part "of it, at leaſt, is retained by the ſulphu-"reous ſcoria; ſo that in this caſe you com-"monly in vain look for a regulus.

"The iron obtained from this firſt preci-"pitation has hardly ever the requiſite duc-"tility, but is rather brittle: the reaſon of "which is, that the ſulphur and arſenic re-"main in it; for notwithſtanding that the "greateſt part of theſe is diſſipated by roaſt-"ing, yet ſome part adheres ſo ſtrictly, that "it can never be ſeparated but with abſor-"bent, terreſtrial, alkaline ingredients, that "change the nature of the ſulphur. For "which reaſon, in larger operations, they "add quicklime, or marble-ſtones that turn "into quicklime; which, while they abſorb "the ſaid minerals, are, by it, and by help "of the deſtroyed part of the iron, brought "to a fuſion, and turn to a vitrified ſcoria; "although, at other times, they reſiſt ſo "much by their own nature a vitrification. "Another cauſe of the brittleneſs of iron is

 the

But the largest quantity of the mercury found in the earth is mineralised by sulphur, and consequently is in the form of cinnabar. *See* CINNABAR.

" the unmetallic earth, when it is not yet " separated from it; for the iron-ore con- " tains a great quantity of it, and in the " melting remains joined with the reguline " part: whence the iron is rendered very " coarse and brittle. Some iron-ores are al- " together untractable: nevertheless, the " regulusses produced out of them, when " broken, have sometimes a neat semime- " tallic look; which proceeds undoubtedly " from a mixture of a small quantity of some " other metal or semimetals.

PROCESS II.

[The following Process for essaying iron-ores, and ferruginous stones and earths, is extracted from Mr. Gellert's *Elements of Essaying*.]

ROAST two quintals of iron-ore, or of ferruginous earth: divide the roasted matter into two equal parts; to each of which add half a quintal of pulverised glass, if the substance be fusible, and contains much metal; but if otherwise, add also half a quintal of calcined borax. If the roasting has entirely disengaged the sulphur and arsenic, an eighth part, or even half a quintal, of quicklime may be added. With the above matters, mix twelve pounds of charcoal powder.

Take a good crucible, and cover the bottom and sides of its inner surface with a paste made of three parts of charcoal-dust and one part of clay beat together. In the hollow left in this paste put the above mixture; press it lightly down; cover it with pulverised glass; and put on the lid of the crucible.

Place two such crucibles at the distance of about four fingers from the air-pipe, in such a manner that the air shall pass betwixt them at about the third part of the height from the bottom: fill the space betwixt the two crucibles with coals of a moderate size: throw lighted coals upon them, that the fire may descend and make them red-hot from top to bottom: at first let the bellows blow softly, and afterwards strongly during an hour, or an hour and a quarter: then take away the crucible, and break it when cold. A regulus will be found in the bottom, and sometimes some small grains of iron in the scoria, which must be separated and weighed along with the regulus: then try the regulus, whether it can be extended under the hammer, when hot and when cold.

Remarks. To disengage a metal from the earthy matters mixed with it by fire, we must change these matters into scoria or glass. This change may be effected by adding some substance capable of dissolving these matters; that is, of converting them into a scoria or glass, from which the metallic matters may, by their weight, separate and form a regulus at bottom. Fixed alkali, which is an ingredient of the black and of the white flux, is a powerful solvent of earths and stones: but the alkali does also dissolve iron, especially when this is in a calcined or earthy state; and this solution is so much more compleat, as the fire is longer applied. Hence, in ordinary essays, where an alkaline salt is used, little or no regulus of iron is obtained. Now, glass acts upon, and dissolves earths and stones; but not, or very little, iron: consequently glass is the best flux for such essays: and experience confirms this assertion. If the ore contains but little iron, we may also add to the glass some borax; but borax cannot be employed singly, because it very soon fuses, and separates from the ore before the metal is revived. Quicklime is added, not only to absorb the sulphur and arsenic remaining in the ore, but also because it dissolves and vitrifies the stony and earthy matters of iron-ores, which are generally argillaceous. For which reason, in the large operations for smelting iron-ore, quicklime and even in certain cases gypsum are commonly added to facilitate the fusion.

The reduction of iron-ore, and even the fusion of iron, requires a violent and long-continued heat: therefore, in this operation, we must not employ an inflammable substance, as pitch, that is soon consumed, but charcoal pulverised, which in close vessels is not sensibly wasted. Too much charcoal must not be added, else it will prevent the action of the glass upon the earthy matter of the ore, and consequently the separation of the metallic part. Experiments have taught me, that

Mercury is never mineralised by arsenic. The richest mine of mercury is that of Almaden, in Spain. (*q*)

that one part of charcoal-dust to eight parts of ore was the best proportion.

When iron is surrounded by charcoal, it is not decomposed or destroyed: hence the iron of the ore, which sinks into the hollow made of paste of charcoal-dust and clay, remains there unhurt. The clay is added in this paste to render it more compact, and to keep the fluid iron collected together.

The air is directed betwixt the crucibles; because if it was thrown directly upon them, they would scarcely be able to resist the heat. The space betwixt the air-pipe and the crucibles ought to be constantly filled with charcoal, to prevent the cold air from touching the crucibles. Ductile and malleable iron is seldom obtained in this first operation. The sulphur and arsenic, and frequently also an earthy matter adhering to the iron, prevent these qualities.

(*q*) ORES *of* MERCURY. Besides the ores of mercury enumerated by the author of the Dictionary, Linnæus and Cronstedt mention a singular ore, in which the mercury is *mineralised by sulphur and by copper*. It is said to be of a blackish-grey color, of a glassy texture, and brittle. When the mercury and sulphur are expelled by fire, the copper is discovered by giving an opake red color to glass of borax, which, by continuance and encrease of heat, becomes green and transparent. *See* CINNABAR.

Cramer directs, that *ores of mercury should be essayed* by the following Processes:

PROCESS I.

[*Cramer's Art of Assaying, Proc.* 58.]

" *To separate Mercury out of an unsulphureous* " *Ore by Distillation.*

" TAKE a lump of the pulverised ore, " one common pound, which must stand for " one centner: put it into a glass retort " perfectly clean, well loricated, or coated " up to half the length of its neck: this must " be very long, and turned backwards with " such a declivity, that a glass recipient may " be perpendicularly applied to it: but you " must chuse a retort small enough, that " the belly of it may be filled hardly two-" thirds with the ore: this retort must be " placed so, that nothing of the fluid adherent to the neck of it may fall into the " cavity of the belly, but that the whole may " run forward into the recipient. Finally, " have a small recipient full of cold water: " let it be perpendicularly situated, and " receive the neck of the retort in such " manner that the extremity of it be hardly " one half-inch immersed into the water.

" Let the retort be surrounded with hot " burning coals placed at some distance in " form of a circle, lest the vessel should burst " by too sudden a heat: then by degrees " bring the burning coals nearer and nearer, " and at last surround the whole retort with " them and with fresh charcoal, that it may " grow slightly red-hot: this fire having " been continued for an hour, let the retort " cool of itself: then strike the neck of it " gently, that the large drops which are always adherent to it may fall into the recipient: let the recipient be taken away, and " the water separated from the mercury by " filtration, and let the mercury be weighed. " This operation may be more conveniently " performed in a sand bath, in which case " the pot containing the sand must be " middling red-hot, and the retort be able " to touch the bottom of it immediately; " nor is it then necessary that the retort be " loricated."

PROCESS II.

[*Cramer's Art of Assaying, Proc.* 59.]

" *To revive Mercury from a sulphureous Cinnabar-ore.*

" BEAT your ore extremely fine, and mix " it exactly with an equal portion of iron-" filings, not rusty; and proceed to distill it " with the same apparatus as in the former " Process; but urge it with the strongest fire " that can be made,

" Cinnabar may be separated from stones " by sublimation thus: Beat it to a fine " powder, and put it into a small, narrow " glass or earthen cucurbit, the belly of " which it must not fill more than one-" third part: stop the orifice at top; this

 " must

DXVIII. ORE *of the* REGULUS *of* ANTIMONY, *or* ANTIMONY. Native regulus of antimony was first observed by Mr. Swab, in Sweden, in the mine of Salberg, and described by him in the Memoirs of the Swedish Academy in 1749. Mr. Wallerius mentions it in his Mineralogy.

Regulus of antimony is generally united with sulphur, with which it forms antimony, which ought to be considered as a true ore of the regulus of antimony.

Another ore of regulus of antimony is also known, of a red color, in which the regulus is mineralised both by arsenic and by sulphur. This ore resembles some iron ores, and some kinds of blend. It is distinguished by its great fusibility, which is such, that it may be easily melted by the flame of a candle. *(r)*

" must be very narrow, to hinder the free " action of the air. Put this small cucurbit " in an earthen pot above two inches wide " in diameter, and gather sand around this " pot about as high as the pulverised ore " rises in the cucurbit. Then put it upon " burning coals in such manner that the bot- " tom of the pot may be middling red-hot. " Thus will your cinnabar ascend and form " a solid ponderous ring, which must be got " out by breaking the vessel."

(r) ORES *of* REGULUS *of* ANTIMONY. 1. The *native regulus* of antimony, observed by Mr. Von Swab, is said by that author to have differed from the regulus of antimony obtained from ores, in these two properties, that it was capable of being easily amalgamated with mercury, and that its calx shot into crystals during the cooling.

Besides the ores of regulus of antimony enumerated in the Dictionary, this semimetal is also found in ores of other metallic substances, as in the *plumose silver-ore*, and in the *stibiated lead-ore*. *See* ORES *of* SILVER *and of* LEAD.

The *ores of antimony may be essayed* by the following processes described by Mr. Cramer.

PROCESS I.

[Cramer's Art of Assaying, Process lx.]

" *To obtain antimony from its ore.*

" CHUSE a melting crucible or an " earthen pot not glaz'd that may contain " some common pounds of the ore of an- " timony, broken into small bits. Bore at " the bottom of the crucible some small holes, " two lines in diameter. Let the bottom of " the vessel be received by the orifice of a " smaller one, upon which it must be put; " and when the ore is put into it, let it be " covered with a tile, and all the joints be " stopt with lute.

" Put these vessels upon the pavement of " a hearth, and put stones all round them at " the distance of six inches. Fill this inter- " mediate space with ashes, so high that " the inferior pot be covered to the upper " brim. Then put fresh and burning coals " upon it, and with a pair of hand-bellows " excite the fire, till the upper vessel grows " red-hot: take off the fire a quarter of an " hour after, and when the vessels are grown " cold, open them. You will find that the " melted antimony has run through the holes " made at the bottom of the upper vessel " into the inferior one, where it is col- " lected.

PROCESS II.

[Cramer's Art of Assaying, Proc. lxi.]

" *To roast crude antimony, or its ore, with or* " *without addition.*

" CHUSE an earthen, flat, low dish, not " glaz'd, and if it cannot bear being made " middling red-hot, cover it over with a " coat of lute without. Spread it thinly over " with crude antimony, or with its ore, " beaten to a pretty coarse powder, not ex- " ceeding a few ounces at once. Put the " dish upon a fire-pan, having a few burn- " ing coals in it: increase the fire till it be- " gins to smoke a little. Meanwhile you " must

DXIX. ORES *of* BISMUTH. Bismuth is chiefly mineralised by arsenic, and generally it is united with other ores, particularly with that of cobalt. (*s*)

" must incessantly move the powder with a " piece of new tobacco-pipe; for this causes " the sulphur to evaporate the sooner. If " you encrease the fire a little too soon, the " powder immediately gathers into large " clots, or even begins to melt. When this " happens, take it immediately off the fire " before it melts entirely. Then pulverise " it again, and finally make a gentle fire un- " der it. Your black shining powder will " assume an ash-color almost like that of " earth, and become more refractory in the " fire; wherefore you may then encrease the " fire till your powder grows middling red- " hot, and let it last till it ceases to smoke. " If you add to your crude antimony pulve- " rised, half or an equal quantity of charcoal " dust, and perform the rest as above, the " roasting will be done more conveniently: " for it does not gather so easily into clots, " and melts with much greater difficulty. " When part of the sulphur is evaporated, " add some fat to it at several times. Thus " you will sooner finish the operation, and " the remaining calx will not be burnt to " excess. However, if it be thus exposed to " too violent and long-lasting a fire, a great " quantity of it evaporates; nor does it " cease entirely to smoak in a great fire. " And it will be enough, if growing mid- " dling red-hot, it does no longer emit the " unpleasant smell of the acid of sulphur."

PROCESS III.

[Cramer, *Proc.* lxii.]

" *To reduce a calx of antimony into a semimetallic* " *regulus.*

" MIX some calx of antimony with a quar- " ter part of the black flux, and put it into " the crucible. Cover the vessel with a tile; " make the fire as quickly as the vessel can " bear it, but not greater than is necessary " to melt the flux. When the whole has been " well in fusion for half a quarter of an hour " (which may be tried with a tobacco-pipe, " taking off the tile) pour it into the melting " cone, which must be warm and done over " with tallow. Then immediately strike " the cone several times. You will find, " when the cone is inverted, a regulus, above " which is a saline scoria."

The methods of *calcining antimony by means of nitre*; of obtaining a *regulus of antimony* without a previous calcination or roasting, by throwing a mixture of powdered antimony, tartar, and nitre into a red-hot crucible, and by fusing this mixture; and of obtaining a *martial regulus of antimony*; are described at the articles of the Dictionary, ANTIMONY, *and* REGULUS *of* ANTIMONY.

(*s*) ORES *of* BISMUTH. I. Bismuth is found *native*, resembling the regulus of bismuth. II. An *ochre* of bismuth, of a whitish yellow color, is mentioned by Cronstedt, and is different from the ore improperly called *flowers of bismuth*, which is a calx of cobalt. III. Bismuth is mineralised; 1. By *sulphur*. This ore has the appearance of galena. 2. With *sulphurated iron*. Bismuth is found also in cobalts (*see* COBALT), and in some ores of silver.

Ores of Bismuth may be *essayed* by the following process.

PROCESS I.

[Cramer, Proc. lxiv.]

" *To melt bismuth from its ore.*

" BISMUTH ore may be melted with the " same apparatus as was directed for the " fusion of crude antimony out of its ore. " [*See* ORES *of* ANTIMONY.] Or you may " beat your ore to a very fine powder, with " the black flux, sandiver, and common salt, " in a close vessel, like the ore of lead, or " of tin, and melt it in a middling fire, " having a draught of air. But as this semi- " metal is destructible and volatile, you must " as quick as possible apply to it that degree " of fire which the flux requires to be " melted; and so soon as it is well melted, " the vessel must be taken out of the fire; " and when it is grown quite cold and bro- " ken, you will find your regulus."

Mr. Gellert directs that ores of bismuth should be essayed by fusing a quintal of pulverised ore with half a quintal of calcined borax,

DXX. ORES *of the* REGULUS *of* COBALT, *or* COBALT. Cobalt is a grey-colored mineral, with more or less of a metallic appearance. Its grain is close; it is compact and heavy, and frequently covered with an efflorescence of peach-colored flowers. Of this several kinds are known. All the true cobalts contain the semimetal called *regulus of cobalt*, the calx of which becomes blue by vitrification. This regulus is mineralised in cobalt by sulphur, and especially by a large quantity of arsenic. Some cobalts also contain bismuth and silver.

Authors have given the name of cobalt to many minerals, although they do not contain the semimetal above-mentioned, but only because they externally resemble the ore of the regulus of cobalt. But these minerals can only be considered as false cobalts. They are distinguishable from true cobalt by trying whether they can yield the blue glass called smalt, and the sympathetic ink. The red efflorescence is also a mark by which true cobalt is distinguishable from the false: but this efflorescence only happens when the ore has been exposed to a moist air.

The principal mines of cobalt are in Saxony, where they are dug for the sake of obtaining zaffre, azure blue, or smalt, and arsenic. Very fine cobalt is also found in the Pyrenean mountains.

Cobalt is heavier than most other ores, from the large quantity of arsenic it contains; and in this respect it resembles the ore of tin. (*t*)

DXXI. ORES *of* ZINC. The proper ore of zinc is a substance which has rather an earthy or stoney than metallic appearance, and is called *calamy*, *calamine*, or *lapis calaminaris*. This stone, although metallic, is but moderately heavy, and has not the brilliancy of most other ores. Its color is yellow, and like that of rust. It is also less dense than other metallic minerals. It seems to be an ore naturally decomposed. The calamine is not worked directly to obtain zinc from it, because this would only succeed in close vessels, and consequently with small quantities, according to Mr. Margraaf's process. But it is successfully employed for the conversion of copper into brass by cementation, by which the existence of zinc in that stone is sufficiently proved.

Mr. Wallerius enumerates also amongst the ores of zinc a very compounded mineral, consisting of zinc, sulphur, iron, and arsenic. This mineral called *blend* resembles externally the ore of lead, and hence has been called *false galena*. These blends have different forms and colors, but are chiefly red, like the red ore of antimony.

Zinc is obtained from certain minerals in the East Indies, of which we know little. (*u*)

borax, and half a quintal of pulverised glass, in order to vitrify the adherent earths and stones which invelop the bismuth. But probably the heat requisite for this vitrification would volatilise part of the bismuth.

If the ore be of the kinds above described, mineralised by sulphur, or by sulphur and iron, a previous roasting would be expedient, which may be performed in the same manner as is directed for the roasting of antimony.

(*t*) The ores of cobalt are enumerated in a note under the article COBALT. The *essay* of cobalt is described at the article REGULUS *of* COBALT.

(*u*) ORES *of* ZINC. I. *Calciform ores* of zinc, according to Cronstedt, are pure or mixed. The pure are indurated, and sometimes crystallised, resembling lead-spar. The mixed

DXXII. ORES *of* ARSENIC. The minerals which contain the largest quantity of arsenic are cobalts and white pyrites, although it is also contained in other ores, it being one of the mineralising substances. But as cobalt must be roasted to obtain the sulphur it contains, the arsenic also which rises during this torrefaction is collected, as we shall see in the article SMELTING *of* ORES, *and the particular articles of each of the metallic substances mentioned in this article.* (x)

mixed ore contains also some calx of iron. This is *calamine*. It is whitish, yellowish, reddish, or brown. II. Zinc is *mineralised*, 1. By *sulphurated iron*. *Ore of zinc.* Wallerius says, lead is sometimes contained in this ore. It is white, blue, or brown. 2. By *sulphur, arsenic, and iron. Blend*, or *pseudo-galena* or *false-galena*, or *black-jack*. See FALSE-GALENA. These are of various colors, white, yellowish, brown, reddish, greenish, black. They consist of scales, or are tessellated. Mr. Cronstedt thinks, that in blends the zinc is mineralised in the state of a calx, and in the ore of zinc, in its metallic state.

Although the minerals above enumerated have been known, from their property of converting copper into brass, to be ores of zinc, yet the method of essaying them so as to obtain the contained zinc was not known, or at least not published, before Mr. Margraaf's Memoir of the Berlin Academy for the year 1746, upon that subject. That very able chemist has shewn that zinc may be obtained from its ores, from the flowers, or from any other calx of zinc, by treating these with charcoal dust, in close vessels, to prevent the combustion of the zinc, which happens immediately upon its reduction, when exposed to air. For this purpose, he put a quantity of finely powdered calamine, or roasted blend, or other calx of zinc, well mixed with an eighth part of charcoal-dust, into a strong, luted earthen retort, to which he fitted a receiver. Having placed his retort in a furnace and raised the fire, he applied a violent heat during two hours. When the vessels were cold, and broken, he found the zinc in its metallic form adhering to the neck of the retort.

The chief difficulty in this operation is to get an earthen retort sufficiently compact to retain the vapor of the zinc, (for it easily pervades the Hessian crucibles, Stourbridge melting-pots, and similar vessels, as may be seen from the quantity of flowers which appear upon their outer surface, when zinc or its calxes and any inflammable matter have been exposed to heat within these vessels) and at the same time sufficiently strong to resist the violent fire which Mr. Margraaf requires.

A pretty exact essay of an ore of zinc may be made in the following manner.

Mix a quantity of pulverized roasted ore or calx of zinc with an eighth part of charcoal-dust. Put this mixture into a crucible capable of containing thrice the quantity. Diffuse equally amongst this mixture a quantity of small grains or thin plates of copper equal to that of the calamine or ore employed, and upon the whole lay another equal quantity of grains or plates of copper; and lastly, cover this latter portion of copper with charcoal-dust. Lute a lid upon the crucible; and apply a red heat during an hour or two. The copper or part of it will unite with the vapor of the zinc, and be thereby converted into brass. By comparing the weight of all the metal after the operation with the weight of the copper employed; the weight acquired, and consequently the quantity of zinc united with the copper, will be known. The copper which has not been converted into brass, or more copper with fresh charcoal-dust, may be again added in the same manner to the remaining ore, and the operation repeated with a heat somewhat more intense, that any zinc remaining in the ore may be thus extracted. A curious circumstance is, that a much greater heat is required to obtain zinc from its ore, by distillation, than in the operation, now described, of making brass; in which the separation of the zinc from its ore seems to be facilitated by its disposition to unite with copper.

(x) ORES *of* ARSENIC. I. Regulus of arsenic is found *native*. It is of a leaden color; it burns with a small flame; and is dissipated, leaving generally a very small quantity of calx of bismuth, or of calx of cobalt, and a very little silver. When it is of a solid and testaceous

DXXIII. OSTEOCOLLA. (y)

testaceous texture, it has been improperly called *testaceous cobalt*, in German, *scherben-cobolt*. II. Calx of arsenic is found in form of powder; *native flowers of arsenic*; or of indurated semitransparent crystals; *native crystalline arsenic*. III. Calx of arsenic is mixed, 1. With *sulphur*: when yellow, it is called *orpiment*; when red, it is called *native realgar*: the difference of color depends on the proportion of the two component parts. 2. With *calx of tin*; *tin-grains*. 3. With sulphur and silver, in the *red silver-ore*. 4. With *calx of lead*, in the *lead-spar*. 5. With calx of cobalt, in the *efflorescence of cobalt*. IV. Arsenic is *mineralised*; 1. With *sulphurated iron*; *arsenical pyrites*. 2. With *iron* only; *white pyrites*, or *misspickel*. 3. With *cobalt*, in all almost cobalt-ores. 4. With *silver*. See ORES *of* SILVER. 5. With *copper*. See ORES *of* COPPER. 6. With *antimony*. See ORES *of* ANTIMONY. *Cronstedt*.

Arsenic may be separated from its ore or earthy matters, with which it happens to be mixed, *by sublimation*, according to the following process of Mr. Cramer. [Art of Assaying, Proc. lxix]

"DO every thing as was said about mercury, or sulphur; but let the vessel which is put into the fire with the ore in it be of earth or stone, and the recipient be of glass, and of a middling capacity. Nor is it necessary that this should be filled with water, so it be but well luted. The fire must likewise be stronger, and continued longer than for the extracting of sulphur. Nevertheless every kind of arsenic cannot be extracted in a confined fire: for it adheres to the matrix more strongly than sulphur and mercury. You will find in the part of the vessel which is more remote from the fire, pulverulent and subtle flowers of arsenic; but there will adhere to the posterior part of the neck of the retort small solid masses, shining like small crystals, transparent, sometimes gathered into a solid sublimate, and perfectly white, if the ore of the arsenic was perfectly pure; which, nevertheless, happens very seldom. The flowers are most commonly thin, and of a grey color: which proceeds from the phlogiston mixt with the mass. They are often of a citron or of a golden color, which is a sign that there is in the mixture some mineral sulphur; and if the sublimate be red or yellow, it is a sign of much sulphur.

"As all the arsenic contained in the ore is not expelled in close vessels, you must weigh the residuum; then roast it in a crucible till it smoaks no longer, or rather in an earthen flat vessel not glazed, and in a strong fire to be stirred now and then with a poker, and then weigh it when grown cold: you will be able thus to know how much arsenic remained in the close vessel; unless the ore contain bismuth."

If the arsenic be sulphurated, it may be purified by triturating it with mercury or with fixed alkali, and by subliming the arsenic from the remaining sulphurated mercury or alkali. *See* ARSENIC. The method of obtaining a regulus of arsenic is described at the article REGULUS *of* ARSENIC.

(y) OSTEOCOLLA is a substance formed by stoney matters filling up the interstices of rotten roots of trees. It has been particularly described by Mr. Gleditsch, and examined chemically by Mr. Margraaf. See Memoirs of the Berlin Academy for the Year 1748. The former author relates, that it is dug from grounds containing fine sand and a fine calcareous earth; and that sometimes the roots of living trees had been found converted into this stoney substance. From Mr. Margraaf's experiments we find, that the osteocolla examined by him was composed of a fine sand, a fine calcareous earth, and some rotten remains of a root. Neuman also says, that he found marine acid in osteocolla. But nothing of that or any other acid could be discovered by Margraaf. Neuman also says, that he totally dissolved osteocolla by means of dilute vitriolic acid. Hence the substances examined by these two chemists seem to have been different. Differences must arise from the different qualities of the soil in which osteocolla is found.

P.

DXXIV. PANACEA (MERCURIAL). This name, which signifies *universal remedy*, is given to a preparation of mercury much employed in the cure of those diseases, against which that metallic substance is effectual. To make the panacea, sweet mercury is to be taken and sublimed nine times, then reduced to a fine powder, and digested in good spirit of wine, which is, lastly, to be distilled off, or only decanted.

Sweet mercury is corrosive sublimate entirely saturated with mercury, and thrice sublimed. Corrosive sublimate is rendered milder by the operations which change it into sweet mercury, and retains nothing of its causticity but a purgative quality; but by the nine sublimations which change sweet mercury into the panacea, the saline qualities of this mercurial preparation are so diminished, that after all these sublimations it has not even a purgative virtue.

These changes are probably produced, because at each sublimation a small quantity of marine acid is separated; so that the panacea contains but very little of this acid, and is little else than very pure mercury, united with that quantity only of marine acid, which is necessary to deprive it of its fluid metallic form, and to give it a saline appearance.

The panacea therefore taken internally produces only the effects of mercury much divided, and in such a state that its molecules may be divided more and more by the action of the vessels and liquors of the body, without being capable of uniting again so as to form fluid mercury. This remedy is therefore very proper for exciting salivations, and produces nearly the same effects as mercury administered by friction and fumigation.

We may employ the panacea with success in venereal diseases, and in others in which preparations of mercury are suitable. It may be given conveniently in pills or in a bolus, mixed with proper substances, and cannot be given in any other manner, because it is insoluble, and is very heavy. The dose of it is from six to twenty-four grains, and even more in some circumstances. *See the article* MERCURY, *for the medicinal uses of this preparation.*

DXXV. P A R T I N G. Parting is an operation by which gold and ſilver are ſeparated from each other. As theſe two metals reſiſt equally well the action of fire and of lead, they muſt therefore be ſeparated by other methods. This ſeparation could not be effected, if they were not ſoluble by different menſtruums.

Nitrous acid, marine acid, and ſulphur, which cannot diſſolve gold, attack ſilver very eaſily; and therefore theſe three agents furniſh methods of ſeparating ſilver from gold, or of the operation called *parting*.

Parting by nitrous acid is the moſt convenient, and therefore moſt uſed, and even almoſt the only one employed by goldſmiths and coiners. Wherefore it is called ſimply *parting*. That made with the marine acid is only made by cementation, and is known by the name of *concentrated parting*. Laſtly, parting by ſulphur is made by fuſion, which the chemiſts call the *dry way*, and is therefore called *dry parting*. We ſhall deſcribe each of theſe methods.

DXXVI. P A R T I N G *by* A Q U A F O R T I S. Although parting by aqua fortis be eaſy, as we have ſaid, it cannot however ſucceed, or be very exact, unleſs we attend to ſome eſſential circumſtances.

1. The gold and ſilver muſt be in a proper proportion; for if the gold was in too great quantity, the ſilver would be covered and guarded by it from the action of the acid.

Therefore when eſſayers do not know the proportion of theſe two metals in the maſs to be operated upon, they diſcover it by the following method.

They have a certain number of needles compoſed of gold and ſilver allayed together in graduated proportions, and the allay of each needle is known by a mark upon it. Theſe are called *proof-needles*.

When eſſayers want to know nearly the proportion of gold and ſilver in a maſs, they rub this maſs upon a touchſtone, ſo as to leave a mark upon it. They then make marks upon the touch-ſtone with ſome of the needles the color of which they think comes neareſt to that of the maſs. By comparing the marks of theſe needles with the mark of the maſs, they diſcover nearly the proportion of the gold and ſilver in the maſs.

If this trial ſhews that in any given maſs the ſilver is not to the gold as three to one, this maſs is improper for the operation of parting by aqua fortis. In this caſe, the quantity of ſilver neceſſary to make an allay of that proportion muſt be added.

This operation is called *quartation*, probably becauſe it reduces the gold to a fourth part of the whole maſs.

2. That the parting may be exact, the nitrous acid or aqua fortis employed muſt be very pure, and eſpecially free from mixture of vitriolic and marine acids. Its purity muſt therefore be aſcertained; and if this be found not ſufficient, the acid muſt be purified by an operation called the *precipitation of* AQUA FORTIS. *See that article.*

If the purity of the aqua fortis was not attended to, a quantity of ſilver proportionable to theſe two foreign acids would be ſeparated during the ſolution; and this portion of ſilver, reduced by theſe acids to vitriol of ſilver and to luna cornea, would remain mingled with the gold, which conſequently would not be entirely purified by the operation.

When

When the metallic maſs is properly allayed, it is to be reduced to plates, rolled up ſpirally, called cornets; or to grains. Theſe are to be put into a matraſs, and upon them a quantity of aqua fortis is to be poured, the weight of which is to that of the ſilver as three to two: and as the nitrous acid employed for this operation is rather weak, the ſolution is aſſiſted, eſpecially at firſt, by the heat of a ſand-bath, in which the matraſs is to be placed. When, notwithſtanding the heat, no further mark of ſolution appears, the aqua fortis charged with ſilver is to be decanted. Freſh nitrous acid is to be poured into the matraſs, ſtronger than the former, and in leſs quantity, which muſt be boiled on the reſiduous maſs, and decanted as the former. Aqua fortis muſt even be boiled a third time on the remaining gold, that all the ſilver may be certainly diſſolved. The gold is then to be waſhed with boiling water. This gold is very pure, if the operation has been performed with due attention. It is called *gold of parting*.

No addition of ſilver is required, if the quantity of ſilver of the maſs is evidently much more conſiderable than that of the gold: perſons who have not proof needles, and other apparatus to determine the proportion of the allay, may add to the gold an indeterminate quantity of ſilver, obſerving that this quantity be rather too great than too ſmall, and ſo conſiderable as to render the maſs nearly as white as ſilver; for a large quantity of ſilver is rather favorable than hurtful to the operation: It has no other inconvenience than an uſeleſs expence, as the larger the quantity is of ſilver, the more aqua fortis muſt be employed. We ought to attend to this fact, that the color of gold is ſcarcely perceptible in a maſs two-thirds of which is ſilver and one-third is gold; this color then muſt be much leſs perceptible when the gold is only one-fourth part, or leſs, of the whole maſs.

If the quantity of gold exceeds that of the ſilver, the maſs may be expoſed to the action of aqua regia, which would be a kind of inverſe parting, becauſe the gold is diſſolved in that menſtruum, and the ſilver is not, but rather reduced to a luna cornea, which remains in form of a precipitate after the operation. But this method is not much practiſed, for the following reaſons.

Firſt, the gold cannot be eaſily ſeparated from the aqua regia; for if the parting has been made with an aqua regia prepared with ſal ammoniac, or if the gold be precipitated by a volatile alkali, this gold has a fulminating quality, and its reduction requires particular operations. If the aqua regia has been made with ſpirit of ſalt, and the precipitation effected by a fixed alkali, the gold will not then be fulminating, but the precipitation will be very ſlow, and probably incompleat. *See* GOLD (FULMINATING).

Secondly, in the parting by aqua regia, the ſilver is indeed precipitated into a luna cornea, and thus ſeparated; but this ſeparation is not perfect, as a ſmall quantity of luna cornea will always remain diſſolved by the acids, if this ſolution even could be only effected by the ſuperabundant water of theſe acids. Accordingly the ſilver is not ſo accurately ſeparated from the gold by aqua regia, as the gold is from the ſilver by aqua fortis. We ſhall afterwards ſee, at the article PARTING (CONCENTRATED), that by this operation, ſilver may be ſeparated from gold without the neceſſity of quartation, although theſe metals ſhould not be in a proper proportion for the parting by aqua fortis.

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The gold after the parting by aqua fortis is much more eaſily collected when it remains in ſmall maſſes, than when it is reduced to a powder.

When the maſs has been regularly quarted, that is, when it contains three parts of ſilver and one part of gold, we muſt employ, particularly for the firſt ſolution, an aqua fortis ſo weakened that heat is required to aſſiſt the ſolution of the ſilver: by which means the ſolution is made gently; and the gold which remains preſerves the form of the ſmall maſſes before the ſolution. If the aqua fortis employed were ſtronger, the parts of the gold would be diſunited and reduced to the form of a powder, from the activity with which the ſolution would be made.

We may indeed part by aqua fortis a maſs containing two parts of ſilver to one part of gold; but then the aqua fortis muſt be ſtronger; and if the ſolution be not too much haſtened, the gold will more eaſily remain in maſſes after the operation. In both caſes, the gold will be found to be tarniſhed and blackened, probably from the phlogiſton of the nitrous acid. Its parts have no adheſion together, becauſe the ſilver diſſolved from it has left many interſtices; and the cornets or grains of this gold will be eaſily broken, unleſs they be handled very carefully. To give them more ſolidity, they are generally put into a teſt under a muffle and made red-hot, during which operation they contract conſiderably, and their parts are approximated. Theſe pieces of gold are then found to be rendered much more ſolid, ſo that they may be handled without being broken. By this operation alſo the gold reſumes its color and luſtre; and as it generally has the figure of cornets, it is called *gold in cornets*, or *grain gold*. Eſſayers avoid melting it, as they chuſe to preſerve this form, which ſhews that it has been parted.

The gold and ſilver thus operated upon ought to have been previouſly refined by lead, and freed from all allay of other metallic matters, ſo that the gold which remains ſhould be as pure as is poſſible. However, as this is the only metal which reſiſts the action of aqua fortis, it might be purified by parting from all other metallic ſubſtances; but this is not generally done for ſeveral reaſons. Firſt, becauſe the refining by lead is more expeditious and convenient for the ſeparation of the gold from the imperfect metals; and ſecondly, becauſe the ſilver, when afterwards ſeparated from the aqua fortis, is pure; laſtly, becauſe moſt imperfect metals do not remain completely and entirely diſſolved in nitrous acid, from the portion of phlogiſton which this acid deprives them of, the gold would be found after the parting mixed with the part of theſe metals which is precipitated.

The gold remaining after the parting ought to be well waſhed, to cleanſe it from any of the ſolution of ſilver which might adhere to it; and for this purpoſe diſtilled water ought to be uſed, or at leaſt water the purity of which has been aſcertained by its not forming a precipitate with a ſolution of ſilver, becauſe ſuch a precipitate would alter the purity of the gold.

The ſilver diſſolved in the aqua fortis may be ſeparated either by diſtillation, in which caſe all the aqua fortis is recovered very pure, and fit for another parting; or it may be precipitated by ſome ſubſtance which has a greater affinity than this metal with nitrous acid. Copper is generally employed for this purpoſe at the mint.

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The ſolution of ſilver is put into copper veſſels. The aqua fortis diſſolves the copper, and the ſilver precipitates. When the ſilver is all precipitated, the new ſolution is decanted, which is then a ſolution of copper. The precipitate is to be well waſhed, and may be melted into an ingot. It is called *parted ſilver*. When this ſilver has been obtained from a maſs which had been refined by lead, and when it has been well waſhed from the ſolution of copper, it is very pure.

Mr. Cramer obſerves juſtly in his Treatiſe on Eſſaying, that however accurately the operation of parting has been performed, a ſmall portion of ſilver always remains united with the gold, if the parting has been made by aqua fortis; or a ſmall portion of the gold remains united with the ſilver, if the parting has been made by aqua regia; and he eſtimates this ſmall allay to be from a two hundredth to a hundredth and fiftieth part, which quantity may be conſidered as nothing for ordinary purpoſes, but may become ſenſible in accurate chemical experiments. (z)

(z) The maſs of gold and ſilver to be quarted, ought previouſly to be *granulated*, which may be done by melting it in a crucible, and pouring it into a large veſſel full of cold water, while at the ſame time a rapid circular motion is given to the water by quickly ſtirring it round with a ſtick or broom.

The veſſels generally uſed for this operation, called *parting-glaſſes*, have the form of truncated cones, the bottom being commonly about ſeven inches wide, the aperture about one or two inches wide, and the height about twelve inches. Theſe glaſs veſſels ought to have been well annealed, and choſen free from flaws; as one of the chief inconveniencies attending the operation is, that the glaſſes are apt to crack, by expoſure to cold, and even when touched by the hand. Some operators ſecure their glaſſes by a coating. For this purpoſe they ſpread a mixture of quicklime ſlaked with beer and whites of eggs upon linen cloth, which they wrap round the lower part of the veſſel, leaving the upper part uncovered, that they may ſee the progreſs of the operation; and over this cloth they apply a compoſition of clay and hair. Schlutter adviſes to put the parting-glaſſes in copper veſſels containing ſome water, and ſupported by trevets, with fire under them. When the heat communicated by the water is too great, it may be diminiſhed by adding cold water, which muſt be done very carefully by pouring againſt the ſides of the pan, to prevent too ſudden an application of cold to the parting-glaſs. The intention of this contrivance is, that the contents of the glaſſes, if theſe ſhould break, may be received by the copper veſſel. Into a glaſs fifteen inches high, and ten or twelve inches wide at bottom, placed in a copper-pan twelve inches wide at bottom, fifteen inches wide at top, and ten inches high, he uſually put about eighty ounces of metal, with twice as much aqua fortis.

The *aqua fortis* ought to be ſo ſtrong as to be capable of acting ſenſibly on ſilver when cold, but not ſo ſtrong as to act violently. If the aqua fortis be very ſtrong, however pure, and if the veſſels be well cloſed, a ſmall quantity of the gold will be diſſolved along with the ſilver, which is to be guarded againſt.

Little *heat* ought to be applied at the beginning, the liquor being apt to ſwell and riſe over the veſſel; but when the acid is nearly ſaturated, the heat may be ſafely encreaſed.

When the ſolution ceaſes, which may be known by the diſcontinuance of the effervеſcence, or emiſſion of air-bubbles, the liquor is to be poured off. If any grains appear entire, more aqua fortis muſt be added, that all the ſilver may be diſſolved. If the operation has been performed ſlowly, the remaining gold will have ſtill the form of diſtinct maſſes, which are to receive ſolidity and color by fire, in the manner directed by the author of the Dictionary. If the operation has been performed haſtily, the gold will have the appearance of a black mud or powder, which after five or ſix waſhings with pure water muſt be melted.

The *ſilver is uſually recovered* by precipitating it from the aqua fortis by means of copper-veſſels into which the liquor is poured, or

DXXV. PARTING (CONCENTRATED). Concentrated parting is alſo called *parting by cementation*, becauſe it is actually performed by cementation. This parting or purification of gold is uſed when the quantity of it is ſo great in proportion to the ſilver, that it cannot be ſeparated by aqua fortis. This operation is done in the following manner.

A cement is firſt prepared compoſed of four parts of bricks powdered and ſifted, of one part of green vitriol calcined till it becomes red, and of one part of common ſalt. The whole is very accurately mixed together, and a firm paſte is made of it by moiſtening it with a little water or urine. This cement is called *cement royal*, becauſe it is employed to purify gold, which is conſidered by chemiſts as the king of metals.

The gold to be cemented is to be reduced to plates as thin as ſmall pieces of money. At the bottom of the crucible or cementing-pot, a ſtratum of cement, of the thickneſs of a finger, is to be put, which is to be covered with plates of gold; upon theſe another ſtratum of cement is to be laid; and then more plates of gold, till the crucible or pot is filled with theſe alternate ſtrata of cement and of gold. The whole is then to be covered with a lid, which is to be luted with a mixture of clay and ſand. This pot is to be placed in a furnace, or oven, and heated by degrees till it is moderately red, which heat is to be continued during 24 hours. The heat muſt not be ſo great as to melt the gold. The pot or crucible is then left to cool, and the gold is to be carefully ſeparated from the cement, and boiled at different times in a large quantity of pure water. This gold is to be eſſayed upon a touchſtone or otherwiſe; and if it be found not ſufficiently purified, it is to be cemented a ſecond time in the ſame manner.

The vitriolic acid of the bricks and of the calcined vitriol diſengages the acid of the common ſalt during this cementation: and this latter acid diſſolves the ſilver allayed with the gold, and ſeparates it by that means.

This experiment proves, that although marine acid, while it is liquid, cannot attack ſilver, it is nevertheleſs a powerful ſolvent of that metal. But for this purpoſe it muſt be applied to the ſilver in the ſtate of vapors, extremely concentrated, and aſſiſted with a conſiderable heat. All theſe circumſtances are united in the concentrated parting.

This experiment proves alſo, that notwithſtanding all theſe circumſtances, which favour the action of the marine acid, it is incapable of diſſolving gold.

Laſtly, the marine acid in this ſtate more effectually diſſolves the ſilver than the nitrous acid does in the parting by aqua fortis, ſince this operation ſucceeds

or of plates of copper which are thrown along with the liquor into glaſs-veſſels. A conſiderable heat is required to accelerate this precipitation. Dr. Lewis ſays, he has obſerved that when the aqua fortis was perfectly ſaturated with ſilver, no precipitation was occaſioned by plates of copper, till a drop or two of aqua fortis was added to the liquor, and then the precipitation began and continued as uſual,

The precipitated ſilver muſt be well waſhed in boiling water, and fuſed with ſome nitre, the uſe of which is to ſcorify any cupreous particles, which may adhere to the ſilver.

From the ſolution of copper in aqua fortis, a blue pigment called *verditer* is obtained by precipitation with whiting. *See* VERDITER.

well when the ſilver is in ſo ſmall a proportion as that it would be protected from the action of the nitrous acid in the ordinary parting.

Inſtead of ſea-ſalt, nitre may be uſed with equal ſucceſs; becauſe the nitrous acid is then put in a ſtate to attack the ſilver, notwithſtanding the quantity of gold which covers it.

Several chemiſts and artiſts uſe both nitre and common ſalt in the cement royal; which ſhews that the acids of aqua regia, applied in this manner at the ſame time to gold and to ſilver, attack the latter metal preferably to the former. (*a*)

The gold muſt be very carefully waſhed after the operation to cleanſe it from particles of diſſolved ſilver, which otherwiſe would ſtick to it.

The ſilver may be ſeparated from the cement by fuſion with a ſufficient quantity of lead and litharge, and by cupelling the lead which retains the ſilver. (*b*)

DXXVIII. PARTING (DRY). Dry parting, or parting by fuſion, is performed by ſulphur, which has the property of uniting eaſily with ſilver, while it does not attack gold.

This method of ſeparating theſe two metals would be the cheapeſt, the moſt expeditious and convenient of any, if the ſulphur could diſſolve the ſilver, and ſeparate it from the gold as well and as eaſily as nitrous acid does: but, on the contrary, we are obliged to employ particular treatment, and a kind of concentration, to begin the union of the ſulphur with the ſilver allayed with gold. Then repeated and troubleſome fuſions muſt be made, in each of which we are obliged to add different intermediate ſubſtances, and particularly the metals which have the ſtrongeſt affinity with ſulphur, to aſſiſt the precipitation, which in that caſe does not give a regulus of pure gold, but a gold ſtill allayed with much ſilver, and even with a part of the precipitating metals; ſo that, to compleat the operation, cupellation is neceſſary, and alſo parting by aqua fortis.

From what we have ſaid concerning this operation we may perceive, that it ought not to be made but when the quantity of ſilver with which the gold is allayed is ſo great, that the quantity of gold which might be obtained by the ordinary parting is not ſufficient to pay the expences; and that it is only proper for concentrating a larger quantity of gold in a ſmaller quantity of ſilver. As this dry parting is troubleſome, and even expenſive, it ought not to be undertaken but on a conſiderable quantity of ſilver allayed with gold. Accordingly, Cramer, Schlutter, Schindler, and all good chemiſts and artiſts who have given proceſſes for the dry parting, recommend its uſe only in the above-mentioned caſes. We wiſh that this operation could be improved: it would be much more advantageous, if it could be done by two or three fuſions; and if by

(*a*) By this method ſome of the gold would probably be diſſolved along with the ſilver. As no advantages are ſaid to attend it, to give it preference to cementation with nitre or with ſea-ſalt ſingly, Dr. Lewis does judiciouſly, I think, diſapprove of it.

(*b*) Gold is never purified by one operation of this kind. It muſt therefore be again melted, beat into plates, and cemented as before. The operation is troubleſome, and is now little uſed, excepting, as Dr. Lewis ſays, for extracting ſilver or baſe metals from the ſurface of gold, and thus giving to an alloyed metal the color and appearance of pure gold.

theſe

these an exact separation could be obtained of a small quantity of gold mixed with a large quantity of silver. (c)

Under the article PURIFICATION *of* GOLD *by* ANTIMONY, we shall see that this purification is a true dry parting, and we shall there find the theory of what passes in that operation.

(c) As this operation for extracting a small quantity of gold from a large quantity of silver is, notwithstanding its inconveniences, approved by Schlutter, Scheffer, and other authors, and practised in Hartz, we shall add to the article in the Dictionary concerning it, what Dr. Lewis, in his excellent History of Gold, has said upon the subject.

The most advantageous method of separating a small portion of gold from a large one of silver appears to be by means of sulphur, which unites with and scorifies the silver without affecting the gold: but as sulphurated silver does not flow thin enough to suffer the small particles of gold diffused through it to reunite and settle at the bottom, some addition is necessary for collecting and carrying them down.

In order to the commixture with the sulphur, fifty or sixty pounds of the mixed metal, or as much as a large crucible will receive, are melted at once, and reduced into grains by lading out the fluid matter, with a small crucible made red-hot, and pouring it into cold water stirred with a rapid circular motion. From an eighth to a fifth of the granulated metal, according as it is richer or poorer in gold, is reserved; and the rest well mingled with an eighth of powdered sulphur. The grains enveloped with the sulphur are again put into the crucible, and the fire kept gentle for some time, that the silver, before it melts, may be thoroughly penetrated by the sulphur; if the fire was hastily urged, great part of the sulphur would be dissipated, without acting upon the metal.

If to sulphurated silver in fusion pure silver be added, the latter falls to the bottom, and forms there a distinct fluid, not miscible with the other. The particles of gold, having no affinity with the sulphurated silver, join themselves to the pure silver, wherever they come in contact with it, and are thus transferred from the former into the latter, more or less perfectly according as the pure silver was more or less thoroughly diffused through the mixed. It is for this use that a part of the granulated metal was reserved. The sulphurated mass being brought into perfect fusion, and kept melted for near an hour in a close covered crucible, one third of the reserved grains is thrown in; and as soon as this is melted, the whole is well stirred, that the fresh silver may be distributed through the mixed, to collect the gold from it. The stirring is performed with a wooden rod; an iron one would be corroded by the sulphur, so as to deprive the mixed of its due quantity of sulphur, and likewise render the subsequent purification of the silver more troublesome. The fusion being continued an hour longer, another third of the unsulphurated grains is added, and an hour after this the remainder; after which the fusion is further continued for some time, the matter being stirred at least every half hour from the beginning to the end, and the crucible kept closely covered in the intervals.

The sulphurated silver appears in fusion of a dark brown color: after it has been kept melted for a certain time, a part of the sulphur having escaped from the top, the surface becomes white, and some bright drops of silver, about the size of peas, are perceived on it. When this happens, which is commonly in about three hours after the last addition of the reserved grains, sooner or later according as the crucible has been more or less closely covered, and the matter more or less stirred, the fire must be immediately discontinued; for otherwise more and more of the silver, thus losing its sulphur, would subside and mingle with the part at the bottom in which the gold is collected. The whole is poured out into an iron mortar greased and duly heated; or if the quantity is too large to be safely lifted at once, a part is first laded out from the top with a small crucible, and the rest poured into the mortar. The gold, diffused at first through the whole mass, is now found collected into a part of it at the bottom, amounting only to about as much as was

DXXIX. PELICAN. A pelican is a glaſs alembic conſiſting of one piece. It has a tubulated capital, from which two oppoſite and crooked beaks paſs out, and enter again at the belly of the cucurbit. This veſſel has been contrived for a continued diſtillation and cohobation, which chemiſts call *circulation.* The volatile parts of ſubſtances put into this veſſel riſe into the capital, and are obliged to return through the crooked beaks into the cucurbit; and this without interruption, or luting and unluting the veſſels.

Although the pelican ſeems to be a very convenient inſtrument, it is nevertheleſs little uſed, and even much neglected at preſent, either becauſe the modern chemiſts have not ſo much patience as the ancient chemiſts had, for making long experiments; or becauſe they find that two matraſſes, the mouth of one of which is inſerted into the mouth of the other, produce the ſame effect. *See Plate* I.

DXXX. PELLICLE. By this word chemiſts mean a very thin ſaline cruſt, which is formed upon the ſurfaces of ſolutions of ſalts, when they are evaporated to a certain degree. This pellicle is nothing elſe than a number of ſaline particles cryſtallized by evaporation at the ſurface of the liquor rather than any where elſe; becauſe the evaporation is made there. Theſe ſmall cryſtals of ſalt at firſt cover the ſurface of the liquor, and give it a duſky ap-

was reſerved unſulphurated. This part may be ſeparated from the ſulphurated ſilver above it by a chizel and hammer; or more perfectly, the ſurface of the lower maſs being generally rugged and unequal, by placing the whole maſs with its bottom upwards in a crucible: the ſulphurated part quickly melts, leaving unmelted that which contains the gold, which may thus be completely ſeparated from the other. The ſulphurated ſilver is eſſayed, by keeping a portion of it in fuſion in an open crucible, till the ſulphur is diſſipated; and then diſſolving it in aqua fortis. If it ſhould ſtill be found to contain any gold, it is to be melted again; as much more unſulphurated ſilver is to be added as was employed in each of the former injections, and the fuſion continued about an hour and a half.

The gold thus collected into a part of the ſilver may be further concentrated into a ſmaller part, by granulating the maſs and repeating the whole proceſs. The operation may be again and again repeated, till ſo much of the ſilver is ſeparated, that the remainder may be parted by aqua fortis without too much expence.

The foregoing proceſs, according to Mr. Schlutter, is practiſed at Rammelſberg, in the Lower Hartz. The prevailing metal in the ore of Rammelſberg is lead: the quantity of lead is at moſt forty pounds on a quintal or hundred pounds of the ore. The lead worked off on a teſt or concave hearth yields about a hundred and ten grains of ſilver, and the ſilver contains only a three hundred and eighty-fourth part of gold; yet this little quantity of gold, amounting ſcarcely to a third of a grain in a hundred weight of the ore, is thus collected with profit. The author above-mentioned confines this method of ſeparation to ſuch ſilver as is poor in gold, and reckons parting with aqua fortis more advantageous where the gold amounts to above a ſixty-fourth of the ſilver: he adviſes alſo not to attempt concentrating the gold too far, as a portion of it will always be taken up again by the ſilver. Mr. Scheffer, however, relates (in the Swediſh Memoirs for the year 1752) that he has by this method brought the gold to perfect fineneſs; and that he has likewiſe collected all the gold which the ſilver contained; the ſilver of the laſt operations, which had taken up a portion of the gold, being reſerved to be worked over again with a freſh quantity of gold-holding ſilver. The ſulphurated ſilver is purified by continuing it in fuſion for ſome time with a large ſurface expoſed to the air; the ſulphur gradually exhales, and leaves the ſilver entire."

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pearance, as if it were covered with dust or with a very thin skin, from which appearance the name of pellicle has been given.

As all crystallizable salts may be crystallized by evaporation alone, in the solution therefore of any of these salts a pellicle may be formed; and also, as all solutions of salts, evaporated till a pellicle is formed, furnish crystals by exposing the liquor to cold, chemists have established a general rule for crystallization, to evaporate solutions of salts till a pellicle is formed, and then to leave them to crystallize by exposure to cold.

This rule is applicable to many salts, but is not general; for some salts, as common salt, do not crystallize by exposure to cold, although the solution of them has been previously evaporated till a pellicle has been formed; while other salts, as nitre and Glauber's salt, may be crystallized in great quantities, although their solutions have not been evaporated so much as that a pellicle has been formed. Hence, to crystallize such salts as common salt, the evaporation must be continued after the pellicle has been formed; and to obtain fine crystals of nitre, Glauber's salt, and others which crystallize in a similar manner, the evaporation must not be continued till a pellicle is formed, but their solutions must be left to cool slowly before it has been so much evaporated. *See* CRYSTALLIZATION *of* SALTS.

DXXXI. PENNY-WEIGHTS. Penny-weights are fictitious parts into which we suppose any mass of silver to be divided, to specify its degree of purity.

Any mass of silver, the purity of which is to be examined, is supposed to consist of twelve equal parts called penny-weights; and if the silver be perfectly fine, and contain no allay, then the twelve parts of the mass are all of pure silver, and this silver is said to be *silver of twelve penny-weights*. If the mass of silver contain a twelfth part of allay, it will then contain only eleven parts of pure silver, and it will be called *silver of eleven penny-weights*, &c.

To expose more precisely the value of silver, each penny-weight is subdivided into twenty-four grains. *(d)*

DXXXII. PEPPER. *(e)*

(d) A *penny-weight* is also a real weight used in the weighing of metals. It is equal to twenty-four real grains, and is the twentieth part of an ounce troy.

(e) PEPPER. Neuman says, that *Pimento*, or *Jamaica Pepper*, appears from a chemical examination to contain, 1. An indissoluble earth, exceeding in quantity all the other principles taken together, and amounting to five drams and a scruple in an ounce. 2. Gummy or mucilaginous matter, which is the ingredient next in quantity. An ounce treated with water at first gave two drams and two grains of gummy extract; and another ounce, freed by rectified spirit from all that the menstruum could dissolve, yielded still with water five scruples of mucilage. 3. A resinous substance in smaller quantity. The resinous extract obtained by applying rectified spirit at first, amounted to only one dram and six grains from an ounce; an ounce freed from its mucilaginous matter by coction in water, yielded of pure resin no more than one scruple. 4. An essential oil in still smaller quantity; of this principle an ounce of pepper contains scarcely half a dram.

Upon examining the qualities of the several products, it appeared, that the oil is the principal and characteristic part, containing all the smell and the aromatic flavor, though not the pungency of the berry. As the prevailing flavor of pimento approaches that of cloves, the oil also greatly resembles the genuine oil of cloves. It has the same kind of smell and taste, discovers no great heat or pungency, and is so heavy as to sink in water:

DXXXIII. PERUVIAN-BARK. (*f*)

DXXXIV. PETROLEUM. *See* BITUMEN.

DXXXV. PETUNTSE. (*g*)

DXXXV. PHLEGM. Chemists have given the name *Phlegm* to the most watery part obtained from bodies by distillation or otherwise.

Phlegm is frequently water mixed superabundantly, and not combined in the bodies from which it is obtained. Such are the phlegms obtained by dis-

water: to which may be added, that the oil of pimento, like that of cloves, resides chiefly in the shell or cortical part, the internal substance yielding little or none. 2. That the heat and pungency are lodged in the resin. In this respect also pimento agrees with cloves: but as pimento in substance is far less hot and fiery than cloves, its resin is also more mild. 3. That the gummy parts have very little activity.

Rectified spirit of wine elevates nothing from this spice in distillation, the oil of pimento being too ponderous to rise with so light a fluid. The only way of making a spirit from it is to dissolve some of the oil in pure spirit of wine. An agreeable spirituous water may be made with proof spirit, the watery phlegm in that liquor carrying up a part of the oil.

The *black pepper* of the East Indies contains an essential oil which has a strong and durable smell, and a taste the mildest of all essential oils. This oil is partly elevated in distillation by rectified spirit of wine; which thereby acquires the flavor, but none of the pungency, of the pepper. The spirituous extract is excessively fiery. The watery extract is also very hot and biting. Neither this menstruum nor the spirit can, singly, extract all the hot matter of the pepper.

Sixteen ounces of black pepper yielded with water ten ounces of gummy extract, and afterwards with rectified spirit three drams of resin: another pound, treated first with spirit, gave two ounces and two drams of resinous extract; and afterwards, with water, seven ounces four drams and two scruples of gummy matter. This last extract had still some degree of pungency, rectified spirit seeming not to take up all the active parts any more than water. Of essential oil, about two drams and a half may be obtained from a pound.

White pepper has the same kind of taste and flavor as the black, but in a much less degree. It agrees also with the black in the nature of its chemical principles; and is, in effect, the same kind of fruit gathered before it is grown fully ripe, and freed from the outer skin. *Neuman.*

(*f*) PERUVIAN BARK. Neuman says, that from a pound of Peruvian bark rectified spirit extracted ten drams and two scruples of resinous matter; and that water extracted from the residuum five drams of gummy matter. He says also, that by applying water first, and afterwards spirit, to the residuum, seven drams and a scruple of gummy matter, and six drams of resinous matter were extracted. To this Dr. Lewis adds the following note. *See* his edition of *Neuman's Works.*

"Different sorts of Peruvian bark differ considerably in their yield of extract. Those which I examined afforded a much larger quantity of resinous extract than Neuman obtained from his.

"It is observable of this drug, says he, that its astringency resides wholly in the resin, which does not appear to be in any degree soluble in watery liquors, but its bitterness in a gummy-resinous substance, or such a one as is soluble both in water or in spirit. Both principles may be extracted by boiling in water, the resin melting out by the heat, and rendering the liquor turbid. The decoction in this state tastes astringent as well as bitter; but on standing it deposites the resin and becomes clear, and then proves simply bitter. Repeated coction and large quantities of water are necessary for extracting all the virtues of the bark: the resin melts out in the first boilings: the decoctions made afterwards are transparent and bitter, without the least turbidness or astringency."

(*g*) PETUNTSE. This is the Chinese name given to a stone which is one of the ingredients of oriental porcelain. It is said to be white, fusible by fire, to give phosphoric light when rubbed, and to have the other properties of the stones called fluors. *See* PORCELAIN.

ſtillation with the heat of a water-bath, from all thoſe vegetable and animal matters which contain no principle ſo volatile as to riſe with a leſs heat than that of boiling water. Theſe phlegms, which are produced merely by drying, are nothing but water almoſt pure, that is, the water of vegetation: but a phlegm conſiſting of water which had been combined in any body, as, for inſtance, the phlegm obtained in the diſtillation of oils, is far from being a pure water. It is ſtill mixed and even united with a ſenſible quantity of the principles of the body, and requires further operations, and chiefly the aſſiſtance of intermediate ſubſtances, to ſeparate it perfectly.

Neither is that phlegm pure water, which, though it is ſuperabundant, yet adheres to certain ſubſtances, eſpecially to thoſe that are volatile. Such are liquid volatile alkalis, and moſt alkalis. By diſtillation we may ſeparate a conſiderable quantity of their phlegm or ſuperabundant water, which operation is called *dephlegmation:* but this phlegm contains always a certain quantity of the ſaline matters with which it was originally mixed.

Hence we may ſee that the word *Phlegm* ſignifies in general the moſt watery part ſeparated from ſeveral bodies, but that it is rarely pure water; and that phlegms differ from each other according to the nature of the ſubſtances from which they are obtained.

DXXXVI. PHLOGISTON. By *phlogiſton* chemiſts mean the moſt pure and ſimple inflammable principle.

Amongſt the various natural bodies, ſome have been obſerved to be capable, by expoſure to fire with the concurrence of air, of being kindled, of producing flame, of augmenting the fire, and of maintaining and ſupporting it; while other bodies, by expoſure to fire, do indeed become hot, red, and luminous; but are incapable of producing flame, or of maintaining fire. Theſe latter ſubſtances do not burn, but only are penetrated by a foreign fire, and ceaſe to be hot and luminous, when this extraneous fire is removed from them.

Theſe bodies are diſtinguiſhed from each other by calling the former *combuſtible bodies*, and the latter *incombuſtible*. Chemiſts have always made a great diſtinction betwixt theſe two kinds of bodies, and have perceived that the inflammability of the former was cauſed by a principle which did not exiſt in the latter: but as this inflammable principle cannot be ſeparated from the other principles of bodies, nor be obtained pure; and, conſequently, as it is impoſſible to diſcover all the properties which are peculiar to it, and which diſtinguiſh it from all other ſubſtances, the ancient chemiſts had very confuſed notions of this inflammable principle; and even now, notwithſtanding all the ſagacity of the greateſt modern chemiſts, this is, of all the principles of bodies, the leaſt accurately known.

The great error of ancient chemiſts was, in not ſufficiently diſtinguiſhing this principle from other more compound bodies, which indeed contain much of it, but of which it is only a conſtituent part. For inſtance, they confounded it with oil and with ſulphur, the names of which ſubſtances were indiſcriminately given to it, although neither oil nor ſulphur be the phlogiſton of the moderns, but are only ſubſtances into the compoſition of which a great quantity of this principle enters.

On the other hand, as oil, ſulphur, and other inflammable matters, differ ſo much from each other that they cannot be conſidered as the ſame thing, probably

bably the ancients, who sometimes gave it one and sometimes another of the names of these inflammable compounds, mistook its unity and identity; that is, they did not know that one only inflammable principle exists, always the same, always similar to itself, either in oils, or in sulphur, or in coals, in a word, in any combustible whatever. We owe the knowledge of these important truths to modern chemists, and particularly to the illustrious Stahl, who has created in some measure a new chemistry, and entirely changed the appearance of this science. All that we shall say concerning phlogiston or fire as a principle of bodies shall be the grounds of the doctrine of that chemist concerning this important matter. To that we shall only add some observations resulting from an attentive examination of the phenomena.

Phlogiston ought to be considered as elementary fire combined, and rendered one of the principles of combustible bodies.

The principal phenomena exhibited by combustible bodies are to kindle, to excite heat and light, to produce the same effects upon other bodies as are produced by the solar rays united in a focus, or by the friction of hard bodies. All these bodies may be inflamed or put into an igneous state by the touch of pure fire rendered active, or, which is the same thing, by the contact of any body actually in the state of ignition.

The combustion of bodies occasions a decomposition and separation of their component principles; and the phenomena of combustion subsist more or less sensibly, till the fire which entered into their composition as a principle be entirely disengaged, exhausted, or dissipated. What remains afterwards of the burnt body belongs to the class of incombustibles. These phenomena leave no doubt that elementary fire enters as a principle into the composition of these bodies. *See* COMBUSTION.

Boerhaave thinks that combustible bodies are not changed into elementary fire during their combustion; because, says he, if it were so, the element of fire would be infinitely encreased: but we may reply, that this event would not happen if this fire, thus disengaged from bodies, be capable of entering into new combinations, and of forming new inflammable bodies; but, from the same reason that it entered into the composition of the first combustible bodies, it may also enter into new similar combinations. Thus, fire continually circulates, like the other elements, which are sometimes pure, free, disengaged from all bodies, and capable of exhibiting all their properties, and sometimes are combined, united with other bodies, and forming compounds in which their properties are more or less disguised and modified by those of the other principles with which they are united; and thus these elements pass alternately in the continued operations of nature from one of these states to the other.

We cannot indeed easily conceive how pure elementary fire, whose parts appear always agitated by a violent motion, and deprived of all cohesion, or of any disposition to adhere in a fixed manner to the parts of other bodies (*see* FIRE) should join, as a principle, in so constant and solid a manner; that is, that each of its primary integrant parts should so strongly unite and adhere to each of the primary integrant parts of any solid body, that it should become deprived of fluidity, mobility, and of almost all the activity which is essential to it. We nevertheless see, from all the chemical phenomena, that the nature and quantity of contact of the integrant and constituent parts of bodies are capable

capable of producing the most surprizing unions and combinations. Facts also demonstrate, that this union of the parts of fire with other bodies really exists; for otherwise we cannot conceive the phenomena of combustible bodies.

The phlogiston, then, or inflammable principle of modern chemists, can be nothing else than the purest and simplest fire, considered in its state of combination, and not in that of aggregation: but we do not yet know whether pure fire be susceptible of combining without any intermediate substance with all the bodies with which we find it united; or whether it cannot enter into these combinations, but by the assistance of an union previously contracted with some substance more disposed than others to combine with it, by means of which it is then rendered capable of entering into all the compounds in which we find it. If this be the case, phlogiston is not pure elementary fire, but this element previously combined with another, and is only a secondary principle. Reasons may be given for and against these opinions, which we shall mention.

First, we shall observe, that chemists have not been able to separate and procure alone what they call the *inflammable principle of bodies*, although they can easily enough procure the other secondary principles. They have only been able to disengage it from bodies by combustion, and then it necessarily resumes the state of pure and active fire, which is well known to be incoercible; or else it is taken from one body by means of another applied to it, with which it unites as soon as it quits the former. In this second case, it is indeed separated from a body without combustion, and without reducing it to actual fire; but it is not obtained alone and pure, since it only quits one combination to enter at the same time into another.

This difficulty, hitherto not surmounted, of obtaining the inflammable principle of bodies in any other state than that of free and active fire, appears to us one of the strongest reasons for believing that phlogiston is nothing else than pure fire, but deprived of its activity by the union it contracts with any substance. If this be the case, phlogiston has no other properties than those of pure fire; or, to speak more accurately, it has no other, as phlogiston, than those which arise from the union of pure fire with the several substances with which it is united. These properties are then peculiar to each of these combinations, and different according to the nature of the substances combined with fire.

However that may be, the power which chemists have of transferring the inflammable principle from one combination to another, with combustion and dissipation, has furnished them with the means of making most important observations on the effects which it produces in many chemical operations, and of remarking the properties which it communicates to the several substances with which it unites. They have compared the properties of a body furnished with its inflammable principle, with those of this same body when deprived of this principle. They have examined the new properties of substances with which they have been able to combine phlogiston. By observing this principle in its progress from one combination to another, and by thus tracing it, Beccher, who called it *inflammable earth*, and Stahl, who called it the *principle of inflammability* or *phlogiston*, have been able to give us much light concerning the nature of this substance, which acts so powerfully in almost all the operations of chemistry.

The

The obſervations of theſe chemiſts, and of ſome others ſince their time, have taught us ſeveral general properties of phlogiſton, which we ſhall firſt relate briefly, without endeavouring to explain them, that they all may be ſeen at once collected, and from one point of view. Beſides, theſe truths will be ſufficiently illuſtrated and proved by the particular relation of the phenomena exhibited by phlogiſton in the ſeveral experiments of chemiſtry, which we ſhall have occaſion to deſcribe.

When phlogiſton is united with an uninflammable ſubſtance, a new compound reſults, which is neither hot nor luminous; but which becomes, by that union, inflammable, and capable of producing heat and light more or leſs eaſily according to the quantity of phlogiſton united with this new compound, and according to the manner in which it is combined.

The principle of fire, by uniting with bodies naturally ſolid, does not render them fluid, but diminiſhes their hardneſs, and renders them more fuſible.

Alſo the compound formed by the union of the inflammable principle with a fixed body is rendered leſs fixed than it was before that union.

It encreaſes the abſolute gravity, and frequently the ſpecific gravity of bodies into which it enters; and in ſome caſes it renders them opake.

Subſtances which have neither ſmell nor color, acquire generally one or the other, and frequently both, by their union with the inflammable principle; and hence chemiſts have been inclined to conſider it as the principle of colors and ſmells. Some bodies indeed, which contain phlogiſton, have neither any ſenſible color or ſmell. But, firſt, we can prove, that theſe bodies contain but a very ſmall quantity of phlogiſton; and, ſecondly, we know no body which contains a large quantity of this principle, which has not more or leſs of color and of ſmell.

Although the compounds in which phlogiſton enters are often very different from each other, yet this principle is not of various kinds, but is always identically the ſame, and ſimilar to itſelf, of whatever nature the bodies may be to which it is united.

Phlogiſton is not equally diſpoſed to unite with all ſubſtances. It combines very difficultly with fluid, volatile, and light matters, ſuch as air and water: perhaps even it never unites with theſe but by means of ſome intermediate ſubſtance; on the contrary, it may be eaſily combined with ſolid, fixed, and heavy ſubſtances, as earths.

Phlogiſton frequently ſerves as an intermediate ſubſtance to unite together bodies incapable of uniting, or very difficultly without it.

We know of no direct combination of phlogiſton with either air or water, that is, we know no body compoſed ſolely of phlogiſton and air, or of phlogiſton and water. But this principle is capable of combining with compounds of which water is a principle: ſuch are oily and ſaline ſubſtances, and particularly vitriolic acid and nitrous acids.

The vitriolic acid cannot unite intimately with phlogiſton unleſs it be dry, that is, unleſs it be deprived of all water ſuperabundant to its ſaline eſſence, extremely concentrated, and contain no water but that which is a principle or conſtituent part of it. From this union an inflammable compound is formed called *ſulphur*. Vitriolic acid in this ſtate quits all bodies to unite with phlogiſton, with which it forms ſulphur; and the ſulphur is always exactly alike, from

from whatever body the phlogiston has been transferred. Thus, whether an oil, resin, fat, coal, or metal, be treated with vitriolic acid, the same sulphur is formed; and since with the same acid all inflammable bodies produce the same compound, therefore the phlogiston of these bodies, however different they may be from each other, is necessarily the same, and consequently this principle is single and identical.

The inflammability of sulphur is caused by the phlogiston it contains; but its flame is not very luminous and ardent; because it contains more vitriolic acid, which is incombustible, than phlogiston.

Sulphur is decomposed by the burning of its phlogiston, which becomes disengaged fire, and dissipates. The vitriolic acid also becomes disengaged, pure, and capable of combining with the phlogiston of another body to form sulphur again, entirely similar to the former.

The vitriolic acid of sulphur is united to phlogiston only, since this acid contains no superabundant water, and also as it is demonstrated that the combustible bodies treated with this acid to form sulphur give it nothing but pure phlogiston. We may therefore discover several of the properties of this principle by comparing sulphur with pure vitriolic acid. The vitriolic acid, which has neither smell nor color when it is pure, forms with phlogiston a compound possessing both these qualities, which are even capable of being rendered much more sensible in some circumstances; as for example, in the combination of liver of sulphur. In the second place, although we cannot certainly know if sulphur be more or less volatile than pure vitriolic acid, because we cannot ever obtain this acid disengaged, without containing at the same time much superabundant water, even when it is in a concrete and glacial form; we have reason, nevertheless, to believe, that sulphur is more volatile than pure vitriolic acid, and that this greater volatility it receives from the phlogiston. This, at least, is evidently indicated by the volatility of sulphureous vitriolic acid, which is infinitely greater than that of simple vitriolic acid.

In the third place, although the disengaged vitriolic acid, particularly when much concentrated, is extremely greedy of moisture, and much more so when deprived of all superabundant water; and although the quantity of this acid be much greater than that of phlogiston in sulphur; yet we see, nevertheless, that sulphur is not soluble in water, which can only be attributed to its phlogiston. This difficulty of uniting with water is common to all the other combinations in which phlogiston is intimately and abundantly combined: for which reason, vitriolic acid cannot form sulphur, unless it be deprived of all superabundant water. This character of dryness, and aversion to unite with water, which the principle of fire preserves in all its combinations, has inclined Beccher to consider it as a principle of a *dry, earthy nature*, and to call it *inflammable earth*, thus signifying an opposition of properties to those of water. We shall not examine now whether Beccher justly made this distinction betwixt what he called a dry and earthy quality, and the humid and aqueous quality; as water is only kept fluid and humid by being penetrated with a certain quantity of disengaged fire, and appears, when deprived of fire, to be as dry and solid as the substances called earthy: but this is certain, that although water perhaps may be essentially as dry as fire, yet these two are of very different natures, and have very little disposition to unite and combine intimately.

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When ſulphur is decompoſed by burning, its acid greedily ſeizes moiſture, as ſoon as it is diſengaged: but as all the phlogiſton does frequently not burn, particularly when the combuſtion is ſlow, a ſmall portion of it remains ſtill united with the aqueous acid. This ſmall quantity of phlogiſton adheres very weakly to the ſulphureous acid, and eaſily ſeparates from it without fire, and merely by expoſure to air: but while it remains united, it communicates properties very different from thoſe which the acid poſſeſſes when pure. The acid is rendered much more volatile; it acquires a pungent, ſuffocating, and inſupportable ſmell; and, laſtly, its ſtrength, or its adheſion to thoſe bodies with which it is capable of uniting, is greatly diminiſhed. It is then called *volatile ſulphureous acid*.

We may obſerve, that although vitriolic acid has a great affinity with phlogiſton, the preſence of water prevents the intimate union of theſe two ſubſtances. Hence, when vitriolic acid is combined with inflammable matters, if any water be contained either in the acid or in the inflammable matter, not ſulphur, but a volatile ſulphureous acid will be formed. Sometimes indeed true ſulphur is formed even in liquors, and by the humid way; but by ſome means the vitriolic acid and the inflammable principle muſt be ſeparated from all ſuperabundant water, elſe the intimate union by which ſulphur is formed, will not happen. *See* ACID (VITRIOLIC), ACID (VOLATILE SULPHUREOUS), SULPHUR, *and* LIVER *of* SULPHUR.

Phlogiſton has alſo a ſtrong affinity with nitrous acid, even ſtronger than with the vitriolic, as we ſhall ſee from the following facts. For, firſt, the volatility of the nitrous acid, its color, its ſmell, its inferiority of ſtrength compared with vitriolic acid; laſtly, its inflammability, and its total decompoſition by inflammation, prove, that phlogiſton enters into the compoſition of this acid, and is one of its conſtituent parts. Stahl and moſt chemiſts think, and with much probability, that nitrous acid differs only from the vitriolic by its containing phlogiſton.

In the ſecond place, nitrous acid acts more ſtrongly in general than vitriolic acid upon all compounds which contain the inflammable principle, and deprives them more effectually of this principle, as is peculiarly obſervable in ſolutions of metals, Beſides, nitrous acid ſeems to act nearly as vitriolic acid does with regard to its combinations with a quantity of phlogiſton ſuperabundant to its compoſition; but ſome differences may be perceived, which ought to be attributed to the inflammable principle which makes part of its combination. Like the vitriolic acid, it cannot unite with phlogiſton in the moſt intimate manner, unleſs it be in a dry ſtate: it then forms a kind of ſulphur which may be called *nitrous ſulphur*, which, from the phlogiſton already contained in the acid, is ſo inflammable, that it kindles as ſoon as it is formed, and therefore has never been obtained alone and uninflamed, as we obtain the vitriolic ſulphur. *See upon this ſubject* DETONATION *of* NITRE.

When the nitrous acid contains ſuperabundant water, it ſtill acts very powerfully upon the phlogiſton of moſt bodies; but no inflammation happens, excepting that during the act of combination, the phlogiſton and acid can be rendered dry; without which circumſtance, only a ſuperficial and weak union of theſe two ſubſtances can be made. The aqueous nitrous acid does indeed attract phlogiſton ſuperabundantly, by which its color, ſmell, and volatility, are

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co siderably en reased; of which we see very evident examples in the solutions of almost all metallic matters by this acid, as of iron, zinc, copper, tin, &c. But then this phlogiston adheres but weakly to the acid, because of the water of the acid, as it does, for the same reason, to the volatile sulphureous acid; and it separates, without heat, by mere exposure to air.

Although nitrous acid be probably capable of thus attracting superabundantly a larger quantity of phlogiston than vitriolic acid, we do not observe, nevertheless, that this superabundant phlogiston produces such a change upon the nitrous acid, as it does upon the pure vitriolic, when it converts this latter into the volatile sulphureous acid. The cause of this evidently is, that nitrous acid in its natural state contains already so considerable a quantity of phlogiston as one of its principles, that it has in a certain degree all the properties of a phlogisticated acid; and these qualities ought not to be changed, but only rendered more sensible by the addition of a superabundant quantity of phlogiston: whereas the vitriolic acid in its pure state, not containing any phlogiston, or at least not sensibly, must, by such an addition, pass from the state of an unphlogisticated acid to that of an acid united with the inflammable principle, when from a pure vitriolic acid it becomes a volatile sulphureous acid, by which it is rendered entirely different. This seems to me to be one of the best proofs that nitrous acid contains phlogiston as a principle and constituent part. *See* ACID (NITROUS).

As the acid of common salt has smell, color, and particularly much volatility, it seems provided with all the properties of an acid united with the inflammable principle. Nevertheless, we do not see that it has the same disposition as the vitriolic and nitrous acids to combine itself with this principle, neither intimately, nor even superficially. On the contrary, it is incapable of acting upon many inflammable matters, for instance, oils; it acts more weakly upon metals, deprives them of less of their inflammable principle, and adheres to them more strongly than the other two mineral acids. Lastly, we do not know any immediate combination of marine acid with phlogiston, that is, any *marine sulphur*; for the phosphorus of Kunckel, which has been believed to be such by Stahl and other chemists, is not a marine sulphur, as we shall see in its place. From what cause then do properties so contradictory proceed? We know too little of the true nature of the marine acid, and of the principle which distinguishes it from the other acids, to be capable of saying any thing satisfactory upon this subject. According to Beccher, the mercurial earth distinguishes this acid from the others. If this be true, the union of phlogiston with marine acid is prevented by this earth. But, on the other side, this earth appears to have many of the properties of phlogiston, both from the properties of marine acid, and from those of metals, which also are supposed to contain mercurial earth: or, is not this union of phlogiston with marine acid prevented by a certain modification of the phlogiston itself contained in that acid, by which its nature is in some measure changed, as Henckel seems inclined to think? Let us hope for further illustration of this obscure matter from time, experience, and the advancement of chemistry. *See* ACID (MARINE).

Fixed alkalis shew in many experiments a considerable disposition to unite with phlogiston. Their properties shew even that this principle is one of their constituent parts; nevertheless, they seem to have less affinity with phlogiston

giston than the vitriolic and nitrous acids, or even than metallic earths. The phenomena exhibited by them when united with inflammable matters have not been sufficiently examined. In some cases, they acquire a very quick and pungent smell, and extreme volatility, as when they are changed into volatile alkali; which happens, as is known, by combining and distilling them with fat matters. In other cases, they may be saturated with an inflammable matter, with which they appear to be intimately united, although they do not acquire the smell and volatility of *volatile alkali*. This happens when they are calcined in close vessels with coals, as in the preparation of the saponaceous alkali for the Prussian blue. Are these two combinations of alkali with phlogiston any thing similar to the combinations of the vitriolic and nitrous acids with the same principle? I am inclined to believe so; but this matter requires further examination. *See* ALKALI (FIXED).

Phlogiston then appears to have a strong disposition to unite with dry and earthy matters, and to adhere to them strongly: but notwithstanding this disposition, we cannot make this combination with any given proportions of these matters, nor with any of the substances containing phlogiston. I do not know that phlogiston would quit the vitriolic acid or metals to unite with a simple earth: we have no reason to presume that this could be effected, unless perhaps by very nice and difficult processes. This is certain, that although these researches be very interesting, as they are connected with the theory of the composition of metals which seem to be formed of earth and phlogiston, they have not been ever made; or, at least, the attempts of chemists upon this subject have not been distinctly published. *See* METALS *and* METALLIZATION.

Several kinds of earths, particularly those the parts of which are naturally very fine and much divided, such as calcareous, and more especially argillaceous earths, appear the fittest to be united with the inflammable principle; and further, phlogiston seems to be most disposed to unite with these earths when it is in the state of oil, of soot, or of vapors. Accordingly, when calcareous or argillaceous earths have been mixed with fat matters, and have afterwards been exposed to the action of fire in close vessels, they retain much of the phlogiston of these matters, which adheres strongly, and communicates color to them, particularly shades of blackness, which cannot afterwards be separated but by a very long calcination in an open fire. In Mr. Macquer's Memoir upon Clays, we may see, that when these earths are exposed to violent fire, although many of them be naturally white, and others become white by a moderate heat, they all acquire colors when exposed to violent fire, apparently from contact of phlogistic vapors; and that these colors, which are black, grey, yellow, greenish or bluish, remain obstinately without any possibility of destroying them. *See* CLAYS.

The coals of vegetable and animal matters are nothing else than singular combinations of the earthy part of these organised bodies with the inflammable principle of their oils and fat. All the properties of coals shew us, that although their phlogiston be in a very combustible state, it nevertheless adheres to them in a very fixed manner, since they can support the most violent fire in close vessels without the least alteration, or loss of any part of their inflammable principle.

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This principle, however, is not ſo adherent to the earth of coals, that it cannot quit it to combine with other ſubſtances, with which it has a ſtronger affinity; for inſtance, with the vitriolic, nitrous and phoſphoric acids, and with metallic earths. Accordingly, coals by expoſure to a violent fire in cloſe veſſels together with any of theſe ſubſtances, are decompoſed, their phlogiſton is ſeparated and combined with the ſubſtance applied to it, with which it forms a new inflammable compound; common ſulphur, for inſtance, with vitriolic acid; nitrous ſulphur with nitrous acid; phoſphorus with phoſphoric acid; and, laſtly, metals, with metallic earths: coal is therefore one of the fitteſt inflammable ſubſtances for tranſmitting phlogiſton to other matters, and therefore is much employed for that purpoſe in chemical operations. *See* COAL.

The properties of phlogiſton are particularly evident and diſtinct in metallic matters. The decompoſition and recompoſition of all imperfect metals and ſemimetals, by the ſubſtraction and reſtitution of the inflammable principle, leaves no doubt that this principle is one of their eſſential conſtituent parts. This is a chemical truth, which may be conſidered as demonſtrated.

We may ſeparate phlogiſton from metallic matters by the general method by which it may be ſeparated from all combuſtible bodies, that is, by combuſtion in open air; for without this condition, the phlogiſton of metals, even the moſt combuſtible, is no more capable of burning in cloſe veſſels than that of coals. *See* CALCINATION, CALX (METALLIC), *and* COMBUSTION.

All mineral acids, and even the combined action of water and of air, are capable of depriving metals of their phlogiſton, which is then done without any combuſtion.

Metals calcined, reduced to calxes or earths by ſome of theſe methods, or rather metallic earths, are capable of combining again with phlogiſton, and of reſuming all the metallic properties by ſeveral methods; that is, by fuſion with coal, or other inflammable matters which are converted into coal during the operation. This is the ordinary method of reducing or recompoſing metals. *See* REDUCTION. Metallic earths may alſo recover their phlogiſton, by applying this principle in the ſtate of vapors, or even by the humid way, by treating them with liver of ſulphur, oils, &c. But the phlogiſton of metals ſeems to be nevertheleſs in a dry ſtate, as well as the phlogiſton of ſulphurs and of coals, as all the properties of metals ſhew. Thus if their earths are capable of recombining with the inflammable principle, even by the humid way in certain circumſtances, the humid combination of phlogiſton muſt be itſelf decompoſed on theſe occaſions, and this principle muſt be ſeparated from all moiſture to combine, at leaſt in an intimate manner, with metallic calxes, and to reduce them into true metals. This reduction is ſimilar to the production of ſulphur in the humid way. *See* REDUCTION *and* SULPHUR.

As the calcination and reduction of metals are performed by the ſeparation and reſtitution of the inflammable principle alone, we may, by comparing the properties of metals with thoſe of their calxes, obtain demonſtrative proofs of many of the eſſential properties of phlogiſton, which we have mentioned in the beginning of this article.

Metallic calxes are generally harder, more ſolid, more fixed, leſs denſe, leſs fuſible, leſs opake than the metals. All theſe qualities then, more or leſs eminent in metals, proceed from phlogiſton. Further, the earths of metals,

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by loſing their phlogiſton, loſe alſo their ſolubility in acids: hence phlogiſton is an intermediate ſubſtance by which metals are diſſolved in acids, from the great affinity which it has with theſe ſolvents. We ſhall now mention ſome particular inſtances of what we have here advanced in general.

Lead and tin are very ſoft metals; nevertheleſs, when lead is calcined and afterwards melted, a glaſs is formed much harder than the lead from which it was produced. Tin, which calcines ſtill more compleatly than lead, is eaſily changeable into a white earth, the parts of which, though very fine, are ſo hard, that they are employed to poliſh very hard bodies, as ſteel, glaſs, &c.

The moſt volatile ſemimetals, as regulus of antimony and zinc, are changed by burning their phlogiſton into perfectly fixed earths.

Regulus of antimony and tin are fuſible with a gentle heat; yet the calxes of theſe metals are juſtly conſidered amongſt the moſt refractory bodies.

The denſity, opacity, and ductility which metals receive from their phlogiſton evidently proceed from the particular manner in which the parts of the phlogiſton are applied to thoſe of the metallic earths. Theſe properties ſeem to ſhew that the primary integrant parts of phlogiſton, although perhaps the ſmalleſt of all imaginable atoms, are eſſentially very denſe and very opake; and alſo, that to give theſe qualities ſo eminently to metals, they muſt be capable of filling very accurately the ſmall interſtices betwixt the primary integrant parts of the metallic earths. The laſt mentioned properties of phlogiſton ſeem to favour the opinion of Beccher and Stahl, who conſider it as an earthy ſubſtance, the parts of which are exceedingly ſmall, not, or but little, coherent to each other, and fitter than any other ſubſtance to acquire the rapid motion in which conſiſt all the effects of fire; or rather, it is the only ſubſtance capable of receiving the igneous motion. *See* METALS *and* METALLISATION.

Although phlogiſton ſhews, in all chemical experiments, a ſtrong repugnancy againſt uniting with water, and even with any ſubſtances containing water, we, nevertheleſs, find it combined with this principle in oils, reſins, and in all vegetable and animal inflammable ſubſtances. We cannot doubt that theſe matters contain water; for it is obtained in their analyſis, and alſo their inflammability ſufficiently proves that phlogiſton is one of their conſtituent parts. Hence we find, that theſe two ſubſtances may aſſiſt in the compoſition of one body: but probably they are not united together immediately in oily compounds, but by means of an earth or rather of an acid; for we know that phlogiſton unites much more readily with earths and acids than with water; and alſo, that earths and acids are obtained in the analyſis of all oily ſubſtances.

As then oils are much more compounded than ſulphurs, metals, and coals, the phenomena exhibited by phlogiſton in oily matters are different from thoſe in theſe other inflammable bodies. Phlogiſton adheres leſs to oily matters, and is more readily combuſtible, and alſo when it is diſengaged by inflammation it is always accompanied with ſome of the other principles of the oily matter which it carries along with it, that is, of the water, acid, and earth which compoſe this matter; all which together form an oily flame. In this combuſtion even all the phlogiſton is not diſſipated: one part of it attaches itſelf much more intimately with the earth of the oil, and forms with this earth a matter black,

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very fixed, and much leſs combuſtible than oil, called *lamp-black* or *ſoot*. It is a kind of coal, and is conſidered by Stahl as almoſt pure phlogiſton.

This fuliginous quality by which oils differ from other inflammable matters, is in a greater or leſs degree, according to the nature of oils, and the greater or leſs activity with which they burn; in general, the more quickly and ſtrongly they burn, the leſs fuliginous matter is formed; ſo that perhaps if an oil was reduced altogether to vapors, it might be burnt in an inſtant without forming any fuliginous matter.

When oils are decompoſed without combuſtion, and by diſtillation, ſomething ſimilar happens. The phlogiſton of the decompoſed part of the oil attaches itſelf to the fixed and earthy part of the oil, intimately unites with it, and forms a coal. In this manner are all coals made.

Oil can tranſmit phlogiſton to all the ſubſtances capable of uniting with it: but in the formation of intimate combinations, as thoſe of ſulphur and metals, the water muſt neceſſarily be ſeparated from the oil. The ſame alſo is obſervable of ſoot and coal, although theſe ſubſtances have been produced from oil itſelf; yet their phlogiſton is never in a ſtate of perfect combination, unleſs they be quite dry. *See* OILS *and* COAL.

Ardent ſpirit and the *ſpiritus rector* of vegetable and animal ſubſtances are alſo compounds in which are contained both phlogiſton and water; for theſe ſubſtances are, at the ſame time, very inflammable and miſcible with water. Beſides, water is obtained in their decompoſition. The phlogiſton of theſe ſubſtances is, nevertheleſs, in a very different ſtate from that of oils; for their flame is leſs luminous, and is not accompanied with any ſoot. The cauſe of this difference probably is, that phlogiſton is more immediately united with water in theſe ſpirits than in oils. Some chemiſts even imagine, that in ardent ſpirits phlogiſton is united to water without any intermediate ſubſtance. The acid is certainly in leſs quantity and leſs ſenſible in ſpirituous inflammable liquors than in oils properly ſo called; and alſo theſe ſpirits may be approximated to the nature of oils, or even changed into true oils, by treating them with acids. *See* OILS, SPIRIT (ARDENT), SPIRITUS RECTOR, *and* ETHER.

From theſe properties of phlogiſton it appears, that it is a principle dry, volatile, ſuſceptible of the igneous motion, capable of combining with primary principles, as earth and water, but much more difficultly with this latter; that it is a component part of many bodies, to which it communicates an inflammable quality; that it is capable of paſſing from one combination to another; and that it is identical, or the ſame in all compounds, as the other principles are. Stahl thinks, that phlogiſton is not elaſtic; and indeed moſt inflammable vapors, in which this principle ſeems to be almoſt pure, are not elaſtic: on the contrary, they deſtroy the elaſticity of the air.

Hitherto the inflammable principle has never been obtained pure and ſingle; and if it be nothing elſe than the matter of elementary fire, we evidently can never obtain it otherwiſe than as we have done; that is, in active and burning fire, by collecting the ſolar rays, &c. Nevertheleſs, in many occaſions phlogiſton diſcovers itſelf without inflammation, if not abſolutely pure and ſimple, at leaſt conſiderably ſo. Stahl believes, as we have already ſaid, that ſoot is almoſt pure phlogiſton. This matter does indeed ſeem to be one of the ſimpleſt combuſtible matters: but its great fixity and ſmall degree of combuſtibility

bustibility prove that in this substance the phlogiston is intimately united with a considerable quantity of very fixed earthy matter, which is capable of disguising many of its essential properties. I believe therefore, that we may consider the very volatile, not inflamed vapors rising from several combustible bodies on certain occasions, as phlogiston still more simple, more copious, and more disengaged. Such, for instance, are the vapors of sulphur formed into liver of sulphur, particularly when it is precipitated by an acid, or exposed when dry to a gentle heat, incapable of kindling sulphur: such also are the vapors of coals of all kinds when they burn weakly and slowly, because then a considerable quantity of the inflammable principle of these coals is exhaled without being inflamed. The subtile vapors disengaged from matters undergoing the spirituous and putrid fermentations, the vapors of mines and subterranean places, called *damps*, appear also to be of the same kind. All these vapors are similar in this respect, that when they are not at liberty to dissipate themselves in open air, they have the property of absorbing air, or of destroying its elasticity, and of acting suddenly upon the brain and nervous system of men and animals, whom they affect with drunkenness, stupefaction, suffocation, syncope, and death. These exhalations are all susceptible of being instantly inflamed, and with more or less explosion, according to circumstances, when they are accumulated and confined in a place, and a lighted substance applied to them. These vapors then are considerably analogous. They all proceed from bodies abounding in inflammable principles, and are themselves inflammable: lastly, when they are applied to any body capable of combining easily with phlogiston, such as, for instance, metallic calxes not much dephlogisticated, they very quickly and easily adhere to it. We seem then to have reason to presume, after all these facts, that these emanations are nothing but the inflammable principle, almost pure, and which is but weakly connected with some other principle.

Such are the chief properties of this principle, the knowledge of which has become so important and essential since the discoveries of Becher, Stahl, Geoffroy, and other modern chemists.

DXXXVII. PHOSPHORUS (ENGLISH), *or* KUNCKEL'S PHOSPHORUS. The name *phosphorus* is applied to all substances capable of giving light in the dark; such as glow-worms, rotten-wood, diamonds after having been exposed to the sun or light, the Bolognian stone, and certain spars after calcination. The effects of these phosphoric matters proceed from electricity, or some property of light. We shall mention these in the following article. The phosphorus we now treat of is of a very different nature. It is a substance not only luminous in the dark, but also inflammable and burning. It is a combination of phlogiston with a peculiar acid, and is consequently a species of sulphur.

The discovery of this phosphorus is not very ancient: it was discovered by a citizen of Hambourg, called Brandt, in his researches for the philosopher's stone. Kunckel was desirous to acquire this secret, and for this purpose associated himself with one of his friends, called *Kraaft*, who thinking by means of it to make a fortune, resolved, after having procured it, not to reveal it, and even obtained a promise from the inventor not to communicate it to Kunckel.

Kunckel,

Kunckel, vexed by this treachery, resolved to search for the phosphorus: and although he knew no more of the process than that urine was the substance employed, he prosecuted this inquiry with such zeal, that at length he made phosphorus. This chemist took to himself very justly the honor of having discovered it, and was accordingly considered as one of the discoverers of it, with so much more reason, as he did not find it by chance, and without searching for it, as Brandt had done, but after a rational inquiry undertaken for this purpose. Accordingly Kunckel's name is affixed to this phosphorus, which is commonly called the *phosphorus of Kunckel.*

The celebrated Mr. Boyle has also had the reputation of having made this discovery. Those who give him the credit of this say, that Boyle having seen a bit of phosphorus in England in 1679, which Kraaft had brought thither to shew to the King and Queen of England, and having been informed only that this phosphorus was produced from some matter belonging to the human body, attempted, like Kunckel, to discover the method of preparing it, and in the following year actually made a small quantity, which he lodged with the secretary of the Royal Society, who gave him a receipt for it. But Stahl, in a small work called the *three hundred experiments*, says that Kraaft told him that he communicated the process to Mr. Boyle. If this be true, Boyle has claimed the honor of a discovery to which he had no right, an imputation injurious to the reputation of a man so justly famous. But we must acknowledge, that the truth of this imputation is very questionable. For Kraaft, who, as Stahl relates, was ignorant of chemistry, who had been treacherous to Kunckel, was nothing in all this affair of phosphorus, but a trader in secrets. For having purchased the secret of preparing phosphorus, he sold it again every where, and therefore no credit is to be given to the testimony of such a man. However that may be, Boyle communicated the process for making phosphorus to a German chemist called Godfreid Hantkwitz, who accordingly prepared it in London. Kunckel and he were then the only persons who made any considerable quantity of it, and the latter made a lucrative trade of it. Stahl says, that he knew also this Mr. Hantkwitz, and considered him as a good practical chemist, and that he had an excellent laboratory in London.

Processes for making phosphorus were frequently published about that time. Mr. Hellot, in his Memoir upon this subject, enumerates all that were then known, namely, the process published by Boyle in 1680, in the Philosophical Transactions, No. 196; that of Kraaft; for, after selling the secret to many persons, he afterwards published it, in a treatise concerning phosphorus written by the Abbé de Commieres, published in the Mercure Galant for June 1683; that of Brandt, in a Collection of Experiments and Observations of Dr. Hook, published by Mr. Derham in 1726; that of Mr. Homberg, in the Ancient Memoirs of the Academy in 1692, who says that he had seen Kunckel make phosphorus; and, lastly, the processes found in the works of several chemists, particularly of Theickmeyer, Hoffman, and Neewentuit.

But notwithstanding all these processes, whether they were not sufficiently compleat, or too laborious and expensive, no chemist, excepting Hantkwitz, made phosphorus, and the operation still continued a secret till the year 1737, when a stranger came into France, who offered to make phosphorus. The ministry granted him a reward for his process, which he accordingly communicated.

municated. Messrs. Hellot, Dufay, Geoffroy, and Duhamel, all experimental philosophers and chemists of the Academy of Sciences, executed this process successfully. Mr. Hellot wrote a distinct account of it, and published it amongst the Memoirs of the Academy of Sciences for the year 1737; a large extract of which may be found in the Elements of Practical Chemistry.

Since the publication of the memoir of Mr. Hellot, the process of phosphorus has been no longer a secret. But as this operation has hitherto been rather curious than useful, and is also expensive and troublesome, I do not know that any French chemist repeated it at that time, excepting Mr. Rouelle, who soon afterwards began a course of chemistry, in which he undertook to make phosphorus in presence of his pupils. I was then present as one of these, and Mr. Hellot attended during the whole operation. We continued there the whole night; but from a fault in the retort, this first operation failed. However, in the years following Mr. Rouelle succeeded many times.

Lastly, in 1743, that intelligent chemist Mr. Margraaf, who had several years been employed in making experiments upon phosphorus, published in the Memoirs of the Academy at Berlin a new and excellent process for obtaining more easily and expeditiously, and at less expence than has been done hitherto, a considerable quantity of phosphorus. This process is repeated successfully every year by Mr. Beaumé in the courses of chemistry which he gives with Mr. Macquer.

To make phosphorus by Mr. Margraaf's process, a kind of plumbum corneum is previously prepared, by distilling a mixture of four pounds of minium with two pounds of powdered sal ammoniac, from which all the volatile alkali, which is very penetrating, is by this operation obtained. The residuum after the distillation, that is, the plumbum corneum, is to be mixed with nine or ten pounds of extract of urine boiled to the consistence of honey. Mr. Margraaf requires that this urine should be putrified, which is unnecessary, according to Mr. Beaumé's observation. This mixture is to be made slowly in an iron caldron set upon the fire, and by frequently stirring the matters. Half a pound of powdered charcoal is then to be added, and evaporation is to be continued till the whole is reduced into a black powder. This powder is to be put into a retort, to extract from it, by a moderate and graduated heat, all the volatile products of urine, that is, volatile alkali, fetid oil, and an ammoniacal matter which adheres to the neck of the retort. In this distillation the heat is to be only raised so as to make the matter red-hot. After the distillation a black and friable residuum remains, from which the phosphorus is to be extracted by a second distillation, and a stronger heat. Before it is exposed to another distillation, it may be tried by throwing some of it upon hot coals. If the matter has been well prepared, a smell of garlic exhales from it, and a blue phosphorical flame is seen, undulating along the surface of the hot coals.

This matter is to be put into a good earthen retort capable of sustaining a violent fire. Mr. Margraaf recommends retorts of *Waldenbourgh*, or those which are made near *Kirchan* in Saxony; which not being known in France, we use Hessian retorts, although they have the inconvenience of allowing a large quantity of phosphorus to transpire during the operation. Mr. Beaumé secures his retorts with a covering of clay and hair.

Three quarters of the retort are to be filled with the matter which is to yield the phosphorus. It is to be placed in the common furnace for distillation with a retort; excepting that instead of being terminated by an ordinary reverberatory or dome, this ought to be terminated by the upper piece of an air-furnace, to which a tube is to be applied, the diameter of which ought to be from four to six inches, according to the size of the furnace, and the height from eight to nine feet. This apparatus, which Mr. Beaumé uses, is necessary for raising a sufficient heat, and for the conveniency of throwing in a sufficient quantity of fuel through the door of the upper piece of the furnace. The retort ought to be well luted to a receiver of moderate size, pierced with a small hole, and half full of water. For this purpose ordinary fat lute may be bound on with strips of linen, dipped in a lute prepared with lime and whites of eggs. The hole in the furnace through which the neck of the retort passes ought to be well stopped with furnace earth. Lastly, a small wall of bricks is raised betwixt the furnace and receiver, to guard this vessel against heat as much as is possible.

All these preparations being made the evening before the distillation is to be performed, we are then capable of proceeding to this operation, which is very easy. The retort is to be heated by slow degrees during an hour and a half; and then the heat is to be encreased till the retort be red-hot, and the phosphorus begin to pass in luminous vapors: when the retort is almost of a white red heat, the phosphorus passes in drops, which fall and congeal in the water at the bottom of the receiver. This degree of heat is continued till no more passes into the receiver. When a retort contains eight pints or more, this operation continues about five hours.

Mr. Margraaf's apparatus is somewhat different from that above described. He divides the whole quantity of matter from which the phosphorus is to be obtained into six small retorts, which he places in a furnace that he describes. The advantage of this division is, that it any accident happens to one retort, the whole matter is not lost; and as the retorts are smaller, a less heat is required. If indeed much phosphorus was to be made, this practice would be safe and excellent; but I can affirm, that the method above described of Mr. Beaumé is very convenient when a large quantity of phosphorus is not wanted, and that I have never seen it fail.

Phosphorus does not pass pure in this distillation, but is blackened by soot or coal, which it carries along with it: It may be easily purified and rendered white and fine by a second distillation or rectification. This rectification is made in a small glass retort, to which is adjusted a small receiver half full of water. A very gentle heat is sufficient, because phosphorus once formed is very volatile: and as the fuliginous matters with which it is soiled were raised merely by the violence of the heat, they remain at the bottom of the retort in this distillation, and the phosphorus passes very pure.

The phosphorus is then usually divided into small cylindrical rolls, for the conveniency of using it. This is done by putting it in glass tubes immersed in warm water. This very gentle heat is sufficient to liquefy the phosphorus, which is almost as fusible as suet. It takes the form of the glass tubes, from which it may be taken out when it is cold and hardened. That it may be more easily taken out of the tubes, these must be somewhat of the form of frustums

of cones. All these operations ought to be made under water, to prevent the inflammation of the phosphorus.

The process published by Mr. Hellot for the preparation of phosphorus is only different from this in two respects; first, that his is only one operation, and not divided into two, as Mr. Margraaf's is; and, secondly, that he does not use plumbum corneum. The operation is certainly much facilitated by Mr. Margraaf's method of separating the volatile matters of the urine by a previous distillation; because after that, nothing more is requisite but to apply heat sufficient to raise the phosphorus; which may be done in four or five hours; whereas without this previous operation, the distillation lasts twenty-four hours. We are not so certain concerning the advantage of adding plumbum corneum, or whether it might not be omitted; for, as this addition does not much encrease the trouble of the operation, chemists who have hitherto made phosphorus by Mr. Margraaf's process have followed it in every point, without making any experiments to determine the necessity of this addition.

Phosphorus is a kind of sulphur composed of a peculiar acid united with phlogiston. This matter is extremely fusible, as we have seen. It has, like sulphur, two kinds of inflammation; one very weak, emitting a flame not powerful enough to kindle other combustible matters, but sufficient for the gradual consumption and burning of its own phlogiston; the other is vivid, brilliant, and strong, accompanied with decrepitation, and capable of kindling instantly any combustible matter. These two flames of phosphorus are easily distinguishable during the distillation of it, when the small hole of the receiver is unstopped; for when the vessels are not too much heated, the flame which issues through the hole is luminous in the dark, but does not kindle any combustible matter; it may be touched without danger, and it only renders the hands that touch it luminous. But when the vessels are too much heated, the flame issues with more force; it then decrepitates, and is capable of burning any person that touches it. This flame is a sign that the heat is too strong; and therefore when it is perceived, the fire ought to be lessened.

Phosphorus resembles vitriolic sulphur also in this point, that all its phlogiston may be burnt, even with rapidity, without any decomposition of its acid.

But it differs from sulphur in being much more combustible. In this circumstance it seems to be in a middle state betwixt the vitriolic and nitrous sulphurs. A heat from twelve to fifteen degrees is sufficient to decompose phosphorus, and to make its phlogiston burn, weakly and slowly indeed, but with a sensible light, particularly in open air. To prevent this decomposition, it must be preserved under water; and even in water it is partly decomposed, and it fills the containing bottle with luminous vapors; its surface loses its semi-transparency, and becomes farinaceous; and the water becomes more and more acid.

When phosphorus is heated by fire, or by friction, it then violently inflames, burns fiercely, and emits many vapors, as sulphur does; which however differ from those of sulphur in smell, which is like that of garlic or arsenic; and also in being always visible, as a white smoke during day, and as a light, when in the dark.

Phosphorus does not seem to be so strongly disposed as sulphur is to unite with metals. Mr. Margraaf has tried to make this combination with all metals

and ſemi-metals. For which purpoſe he took ſome filings of each metallic ſubſtance, digeſted it with two parts of phoſphorus, and diſtilled the mixtures. In all theſe experiments part of the phoſphorus paſſed into the receiver, as when it is rectified; the other part was burnt, and the metals remained untouched, excepting copper and zinc, which were acted upon in the following manners.

Copper treated by Mr. Margraaf with phoſphorus loſt its metallic brilliancy, and became more compact; a gros or 72 grains of copper being twice treated in this manner with phoſphorus, was found to have acquired ten grains in weight, and to be rendered capable of being kindled when expoſed to flame.

Zinc treated twice with phoſphorus in the ſame manner, and expoſed to ſtrong heat at the end of the ſecond diſtillation, was ſublimed almoſt entirely in form of light pointed flowers of a reddiſh-yellow color, which being put under a muffle, were inflamed and vitrified, forming a tranſparent glaſs like that of borax. From theſe experiments we ſee that phoſphorus has little diſpoſition to unite with metals, which property perhaps proceeds from the facility with which it is decompoſed.

According to the experiments of the ſame Mr. Margraaf, phoſphorus ſublimes with arſenic into a compound of a ſhining red color, in which reſpect it reſembles common ſulphur. It eaſily unites with ſulphur. Equal parts of theſe two matters being mixed together and diſtilled, paſſed into the water of the receiver, congealed there, forming a ſubſtance which when rubbed by the fingers, could not eaſily be inflamed, but gave a yellow light, and readily kindled when expoſed to a heat nearly equal to that of boiling water. Mr. Margraaf ſays, that this compound had a fœtid ſmell, like that of liver of ſulphur; and that it ſwelled in water, to which it gave a ſulphureous ſmell, and manifeſt acidity; which effects prove a decompoſition of theſe ſubſtances.

Mr. Margraaf treated phoſphorus alſo with the three mineral acids by diſtilling them together in a retort; and theſe experiments furniſhed very curious obſervations. Vitriolic acid decompoſed almoſt entirely phoſphorus, but without any inflammation. Nitrous acid attacked it with violence, even without the help of fire, and occaſioned a ſudden inflammation, with exploſion and rupture of the veſſels. Laſtly, marine acid produced no alteration upon phoſphorus, nor was itſelf altered. Theſe phenomena are perfectly analogous to the affinities of the three mineral acids with the inflammable principle.

Phoſphorus is ſoluble in oils and inflammable liquors, nearly as ſulphur is, and conſequently forms *balſams of phoſphorus*. But when combined with theſe ſubſtances, it ſeems to be more diſpoſed to decompoſe, than when it is alone; for theſe oily phoſphoric liquors are always luminous, particularly when they are heated a little, and are expoſed to air.

But phoſphorus differs eſſentially from ſulphur by the nature of its acid, which is not yet well known by chemiſts. They believed a long time that it was the ſame as marine acid: Stahl was of this opinion, and others received it. That great chemiſt, in other reſpects ſo accurate and ſo much to be credited, was induced to this opinion by conſidering that urine contains much common ſalt, and that common ſalt expoſed to contact of burning fuel is reduced to flowers, makes the coals burn more intenſely, and occaſions a flame ſimilar to that of phoſphorus. We have reaſon to wonder that ſuch a chemiſt

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as Stahl should pronounce concerning the nature of this acid from so slight reasons, when we consider that the properties of the phosphoric are so very different from those of the marine acid. But we shall be more surprised to find that he positively affirms, in his book called *Three Hundred Experiments*, that to make phosphorus, nothing more is requisite, but to mix and combine properly marine acid with phlogiston; and that by prosecuting what he had published concerning the artificial composition of sulphur, we may make phosphorus as abundantly and easily as sulphur itself.

We cannot wonder that chemists, trusting to so great an authority, shou'd have firmly believed that the acid of phosphorus was the same as marine acid. Accordingly when Mr. Margraaf undertook to simplify and improve the process for phosphorus, he made many experiments to combine marine acid directly with phlogiston. We see in his memoirs, that he made these trials not only by employing common salt, but also several combinations of its acid with other bases. He employed *sal ammoniac*, *corneous metals*, and *marine salt* with earthy bases. He also varied the matters which were to furnish the inflammable principle; instead of urine he employed several vegetable coals, and even other animal matters, such as the oil of hartshorn, human blood, &c. But all these experiments were unsuccessful, or yielded but a very small quantity of phosphorus. He found the necessity of returning to the use of the extract of urine: and Mr. Margraaf having tried to distil it alone, and being assured by comparative experiments that this extract produced as much phosphorus when he distilled it alone as when he mixed it with matters capable of furnishing marine acid, as, for instance, luna cornea, this able chemist then suspected that the phosphoric acid was different from that of common salt.

On the other side, as urine contains, besides common salt, a considerable quantity of a singular kind of salt, which chemists call *fusible salt*, or *native salt of urine* (*See* Urine), Mr. Margraaf, who found that he could not obtain phosphorus from common salt, nor from any of the combinations of its acid with other bases, was naturally led to suspect that this native salt of urine contained the true phosphoric acid. This he afterwards ascertained by many demonstrative experiments. Having distilled this salt only with inflammable matters, he easily obtained a very large quantity of phosphorus; and also having distilled an extract of urine, from which he had separated all the fusible salt, and having by this method obtained scarcely any phosphorus; and, lastly, having examined and compared the properties of the phosphoric acid with those of the acid of the fusible salt, and having found them entirely the same, he acquired on this subject all the certainty which is possible. We shall see from the enumeration of the properties of phosphoric acid, how much it differs from the marine, and all other acids. To Mr. Margraaf also we owe the knowledge we have concerning this important subject.

When the inflammable principle of phosphorus burns, and separates from the acid by this combustion, the acid remains disengaged, as the acid of sulphur does, by the combustion of sulphur. We obtain then, after the combustion of phosphorus a substance at first dry, but which quickly and powerfully attracts the moisture of air, because the acid is so concentrated as to be dry. This matter is soon reduced to a very acid liquor, of the consistence of very concentrated vitriolic acid. It has an acid taste, it converts the blue color of vegetables to a red, and combines to the point of saturation with

alkaline

alkaline ſubſtances. Thus its acid quality is not doubtful. The fixity of this ſalt is very ſingular. It not only may be deprived by heat of all the moiſture by which it is kept liquid, but alſo when thus dried it may be rendered red-hot without ſublimation, and may be thereby changed into a ſolid and tranſparent matter, which has all the appearance of glaſs. Mr. Margraaf obſerved that phoſphoric acid, thus dried and heated, emitted a ſmell of garlic, and alſo ſome luminous ſparks; which proves that phoſphorus does not loſe by combuſtion all its phlogiſton, but that a portion of it ſtill remains united with the acid, and which ſeems to have been protected from combuſtion by this acid.

Phoſphoric acid appears to be a very powerful ſolvent. It eaſily decompoſes nitre and common ſalt, from which it diſengages the acids and unites with the alkaline baſes, as vitriolic acid does. According to Mr. Margraaf's experiment, it alſo decompoſed vitriolated tartar. Theſe remarkable properties ought probably to be attributed to its great fixity.

When it is combined to the point of ſaturation with alkaline ſalts, it forms neutral ſalts entirely ſimilar to the fuſible ſalt of urine.

Mr. Margraaf has alſo examined the action of the phoſphoric acid upon metals. From theſe experiments we find that this acid does not diſſolve gold, not even when mixed with the nitrous acid; which proves that it is very different from marine acid. It does not attack ſilver. It acted a little upon filings of copper, which rendered it green, but it eaſily diſſolved the calx of copper. Iron is entirely and eaſily ſoluble in this acid, and forms with it a cryſtallizable metallic ſalt. Tin is only weakly corroded by this acid, which muſt be well concentrated to produce even this corroſion. It has nearly the ſame effect upon lead. The color only of mercury, precipitated *per ſe*, is changed from a red to a yellow and a white, and by a long digeſtion to a black. It entirely diſſolves white arſenic. Laſtly, it diſſolves perfectly zinc, from the ſolution of which a fetid ſmell ariſes. This acid when treated by fuſion with metallic ſubſtances exhibits nearly the ſame phenomena, only with greater force; and with thoſe metallic matters which contain much diſengaged phlogiſton, as tin, lead, and eſpecially iron and zinc, it forms phoſphorus. Mr. Margraaf obtained a large quantity of excellent phoſphorus by diſtilling, with ſtrong heat, zinc and phoſphoric acid.

We ſhall now ſhew what effects are produced by this acid, when added to ſolutions of metals by other acids. At firſt it produces no change upon the ſolution of gold in aqua regia; but ſome time afterwards it precipitates part of the gold in its metallic ſtate. It affects the ſolution of ſilver nearly in the ſame manner, only that the quantity of ſilver thus precipitated, which reſembles ſilver precipitated by copper, is ſo ſmall, that it cannot be eſtimated. Mr. Margraaf adds, that by diſtilling to dryneſs this mixture of ſolution of ſilver with phoſphoric acid, a matter remained which did not differ from a *tranſparent luna cornea*. Nevertheleſs it was found to be not a true luna cornea, but a mixture only of ſilver with phoſphoric acid: for this matter, when placed upon a coal and heated with a blow-pipe, melted into a dark-grey glaſs. From the ſolution of mercury in nitrous acid, a copious white precipitate is formed by means of phoſphoric acid. But a ſingular circumſtance is, that this precipitate is rediſſolved, when the mixture has remained ſome time expoſed to the cold. Mr. Margraaf adds, that having diſtilled this mixture, he obtained a con-

a considerable quantity of a white and shining mass, which by the heat of a blow-pipe was vitrified into a very transparent glass. But this circumstance seemed very extraordinary, that after he had mixed the residuum with pure lead, and cupelled this mixture, he obtained a regulus of fine silver, the quantity of which was at the rate of six drams per quintal. A white precipitate was made from a solution of lead in nitrous acid by the phosphoric acid; but this precipitate was not redissolved.

These are the properties of phosphorus, and of the phosphoric acid; most of which were discovered and ascertained by Mr. Margraaf. They shew that this acid differs no less from the marine than from other acids, and that its nature is peculiar. Mr. Margraaf, probably from the respect he has to the opinion of Stahl, does not absolutely decide that it is different from the marine acid, but he says that it certainly is not pure and crude marine acid. He thinks, that possibly it may be marine acid very intimately combined with some subtle vitrescible earth. And indeed the fixity and vitrescibility which principally distinguish the phosphoric acid, seem to shew that it contains a larger quantity of such a principle than all other acids.

The phosphoric acid seems at the same time to partake of the nature of *sedative salt* and of *white arsenic*. Sedative salt, without having very distinct acid properties, acts as in acid on many occasions. It combines with alkalis, saturates them, and reduces them to neutral salts. It is fixed in the fire, in which it melts as a vitrescent matter, like the phosphoric acid; like which also it decomposes neutral salts. *See* BORAX *and* SALT (SEDATIVE).

Arsenic is not indeed fixed, as the phosphoric acid is; and it decomposes no other neutral salt than nitre: but it is disposed to vitrification, and has a smell entirely similar to that of the phosphoric acid.

Phosphoric acid is not found solely in animal urine. Mr. Margraaf found that many vegetable matters, particularly farinaceous grains, contain enough of this acid to produce phosphorus, when they are exposed to great heat in close vessels. This acid therefore is probably formed in the vegetable and animal kingdoms, and passes from the former into the latter: but the largest quantity of it is found in urine. *See* URINE *and* SALT (FUSIBLE) *of* URINE.

Hitherto phosphorus has not been employed for any useful purpose. But we may hope that some use might be found for it, particularly if it could be made in large quantities and cheap, for its dearness has certainly prevented the proper trials and researches for this purpose. Although it were only to remain an object of curiosity, it would still be amongst the first of that kind. Many amusing experiments may be made with phosphorus, which would be more surprizing if it were less known. For instance, one may write upon a wall with a roll of phosphorus, and the writing will presently appear in letters of fire. The face, or any other object, may be covered over with phosphorus dissolved in oil, by which it is rendered luminous in a dark place, particularly if the air be heated a little. A taper may be extinguished, and instantly kindled by applying to the wick while yet hot the point of a knife, to which a piece of phosphorus has been fixed by means of suet. Finally, it is one of those substances, by which such magicians as *Comus* may perform operations which greatly surprize those who are not in the secret.

DXXXVIII.

DXXXVIII. PHOSPHORIC STONES. These stones, when properly calcined, have the property of shining in the dark. The most celebrated and most anciently known phosphorus of this kind, is that called the *Bolognian stone*, from Bolognia, a city of Italy, near which this stone is found. Lemery relates, that the person who first discovered the phosphoric property of this stone was a shoe-maker, called Vincenzo Casciarolo, who used to make chemical experiments. He says that this man, walking at the foot of Mount Paterno, gathered some of these stones, the great weight and lustre of which had induced him to believe that they contained silver; and that after having exposed them to fire, and carried them into a dark place, by accident probably, he perceived the stones shining like hot coals, which much surprized him, and induced him to repeat the experiment. From that time the Bolognian stone has been operated upon by chemists and experimental philosophers, who have searched for the most advantageous method of calcining it to render it luminous.

For this purpose we find different processes in the works of La Poterie, of Montalban, of Mentzel, of Lemery, and in the Memoirs of Homberg and du Fay, printed amongst those of the Academy. But nobody has treated this matter so fully, or illustrated it so well, as the celebrated Mr. Margraaf in two Dissertations upon this subject. Wherefore, without attending to what has been said before him, we shall relate here summarily his opinion concerning the nature of Bolognian stones, his method of preparing them, the phenomena they exhibit, and the matters analogous to them; so that the whole of this article shall be extracted from the Dissertations of that able chemist.

Bolognian stone is soft, friable, heavy, crystallized, and incapable of effervescing with acids before it has been calcined in contact with fuel. These qualities have induced Mr. Margraaf to class it amongst the heavy fusible spars, and with so much more justness, as all these spars by a preparation similar to that for the Bolognian stone are rendered phosphoric. As these spars are also composed of the same principles, as we shall afterwards see, all that we shall say concerning the Bolognian stone is also applicable to all other stones of the same kind; that is, to all the heavy fusible spars, or rather to the *selenitic* spars.

When these stones are to be rendered phosphoric, such of them ought to be chosen as are the cleanest, best crystallized, most friable, most heavy, which exfoliate when broken, and, lastly, which contain no heterogeneous parts. They are to be made red-hot in a crucible, and reduced to a very fine powder in a glass mortar, or upon a porphyry. Lemery affirms, that this pulverization ought to be made in a brass mortar, and positively declares, that after many experiments, he found that the operation entirely failed, if any other, particularly an iron mortar, has been used. But Mr. Margraaf, whom we preferably follow, forbids expresly the use of a copper mortar, and affirms that it hurts the success of the operation. The stones having been thus reduced to powder, are to be formed into a paste with gum tragacanth, and divided into cakes as thin as a knife. These are to be dried by a heat, which at last is to be made pretty considerable. After these preparations, an ordinary reverberatory furnace is to be filled to three quarters of its height with charcoal, and the fire is to be kindled. Upon this charcoal the flat surfaces of the cakes are

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to reſt; and more charcoal is to be placed above them, ſo as to fill the furnace. The furnace is then to be covered with its dome, the tube of which is to remain open; all the coal is to be conſumed, and the furnace is to be left to cool. The cakes are then calcined, and are to be cleanſed from the aſhes by blowing with bellows upon them. When they have been expoſed during ſome minutes to light, and afterwards carried into a dark place, they will ſeem to ſhine like hot coals, particularly if the perſon obſerving them has been ſome time in the dark, or have ſhut his eyes, that the pupils may be ſufficiently expanded. Mr. Margraaf obſerves, that after this calcination through the coals, if the ſtones be expoſed to a ſtronger calcination during a full half-hour under a muffle, their phoſphoric quality will be rendered ſtronger.

The phenomena exhibited by theſe ſtones rendered phoſphoric by calcination are very worthy of attention, but are not well underſtood. The difficulty attending this ſubject, is encreaſed by the contradictory relations of thoſe who have operated upon this matter, in ſome important facts. Mr. du Fay, who has publiſhed a Memoir concerning this kind of phoſphorus in the year 1730, aſſerts, from experiments, that all calcareous ſtones, whether they contain, or not, vitriolic acid, are capable of becoming luminous by calcination; with this difference only, that the pure calcareous ſtones require a ſtronger or more frequently repeated calcination; whereas thoſe which contain an acid, as ſelenites, gypſums, ſpars, become phoſphoric by a ſlighter calcination. Mr. Margraaf, on the contrary, who does not ſeem to have known this Memoir of Mr. du Fay, ſays, that no other ſtones can be rendered phoſphoric but thoſe calcareous ſtones only which are ſaturated with an acid; that purely calcareous ſtones, as marble, chalk, limeſtone, ſtalactites, are incapable of receiving this phoſphoric quality, till they have been previouſly to their calcination ſaturated with an acid. The cauſe of this phoſphoric property cannot be aſſigned till theſe facts are aſcertained: for if all calcareous ſtones are capable of being rendered luminous without the concurrence of an acid, we may then ſuſpect that light is capable of adhering more to ſome bodies than to others, and that calcination gives to calcareous ſtones the property of retaining a larger quantity of light, and during a longer time, than other bodies can. We muſt nevertheleſs confeſs that this conjecture is very vague, and not much ſupported by facts.

But if theſe ſtones cannot be rendered luminous without the concurrence of an acid, as Mr. Margraaf thinks, and as experiments indicate; if even the acid does only contribute conſiderably to give them this property, as all experiments upon this matter, and even thoſe of Mr. du Fay, ſeem to ſhew; we then have reaſon to believe, that acids have a conſiderable ſhare in the production of this luminous property. Our conjectures upon this ſubject are as follow.

We know that acids in general, and particularly the vitriolic and nitrous, have a ſtrong affinity with the inflammable principle; that when they are united with this principle, they form with it compounds poſſeſſed of the properties of ſulphur or of phoſphorus. We are alſo certain that ſulphur, phoſphorus, and probably other compounds of acid and phlogiſton with which we are not acquainted, have each two methods of burn-

ing; the first vivid and strong, in which their phlogiston forms a very sensible flame, and produces not only light, but also so considerable a heat as to kindle combustible bodies; the other slow and weak, capable only of producing a light much less vivid, without any sensible heat, or with a heat too small to kindle combustible bodies. Such, for instance, is *gun-powder*. *See* SULPHUR, PHOSPHORUS, *and* POWDER (GUN).

This being established, may we not with probability believe, that the acid contained in stones rendered phosphoric by calcination combines with the phlogiston of the coals, forming with it a sulphureous compound; and that the phlogiston of this kind of sulphur or phosphorus adhering but weakly to the acid, or existing there perhaps only superabundantly, is very easily combustible; so that merely the action of the heat and light of the open air is sufficient to inflame it: not, however, so strongly as to produce heat and a total dissipation of the phlogiston, as when sulphur and phosphorus are burnt, but so slowly, and weakly, that but a very faint light, observable only in the dark, is produced. Such is the light of the Bolognian and of other phosphoric stones of the same kind.

Several phenomena of this phosphorus seem capable of confirming this conjecture. First, the Bolognian stone, the spars and gypsums which are rendered luminous by calcination, have, according to all those who have operated upon them, a smell of sulphur after their calcination, and preserve this smell while they have the phosphoric quality.

Secondly, the calcination of these stones must be made in contact with coals, otherwise they are not rendered luminous, as Mr. Margraaf has observed. But we are certain that this is one of the conditions necessary for the production of all sulphurs, and of phosphorus of all kinds: and as this calcination is also made with the concurrence of the air, and succeeds better in this manner than in close vessels, the sulphureous compound formed in this operation is probably in a state of inflammation and combustion during the calcination, which gradually diminish as the stone cools, so as to be rendered insensible by means of the great quantity of incombustible stoney matter with which the sulphureous compound is covered and surrounded on all sides: the combustion, however, does not so entirely cease, but that merely the action of light is capable of renewing and encreasing it, so as to render it sensible in the dark.

Thirdly, Mr. Margraaf has observed, that every phosphorus of that kind which requires to be exposed to light in order to make it shine in the dark, may, without any such exposure, during two or three days or more, be rendered very luminous merely by being heated; that is, by contact of any hot substance, which is at the same time incapable of giving light; as, for instance, a plate of iron heated, so as not to show the least redness even in the dark. This curious experiment shews very clearly, that the phosphoric light proceeds from a very weak and slow inflammation, which is so checked by cold, that no sensible light proceeds from it, even in the dark, but which may be encreased and renewed by a very weak heat. This matter might be further illustrated by observing the effects of exposing this phosphorus to a great degree of cold at the time of its being very luminous. We should probably find that its light would be gradually diminished, and at length extinguished by the cold.

Thus

Thus we have strong reasons to believe, that the light of all these phosphoric stones is nothing but a very slow and weak combustion or inflammation of a certain quantity of phlogiston which they contain.

Many facts may indeed be objected to this opinion. 1. If the light of this phosphorus was only the effect of a true inflammation, it could not take place without the free access of air; and it would be extinguished, like that of other inflamed substances, when phosphorus is immersed in water or any other liquid. But we are certain that these phosphoric stones have the same effects when they are kept in bottles hermetically closed, or even when immersed under water, as Mr. de Fay has shewn. 2. Mr. de Fay found by experiments, that stones purely calcareous, and containing no acid, are nevertheless rendered phosphoric by calcination. But no sulphureous or phosphoric compound can be formed in these stones. Their light therefore does not seem to depend on any inflammation

To these objections we may answer, that although in general inflammable bodies cannot burn with access of air, this rule is not however free from exceptions, in the instances of sulphureous and phosphoric compounds, particularly concerning that kind of inflammation which is weak and incapable of kindling other combustible matters, which must be carefully distinguished from their rapid combustion, as we have already remarked. We are certain that this weak and slow inflammation of such bodies may subsist without access of air, or at least with much less air than is necessary for the other inflammation, and proportionable to its weakness. We cannot doubt that the light proceeding from the phosphorus of urine is an effect of a weak combustion of this phosphorus, as may be seen under the article PHOSPHORUS *of* KUNCKEL. But this light is well known to appear in water, in oil, in the best closed glass vessels, to encrease by heat and to diminish by cold, which also happens to the phosphoric stones. Besides, although these stones may shine as well as phosphorus in water and in vessels perfectly close, their light is still weaker than in open air, and is much more quickly extinguished in water or other liquors than in air, according to the experiments of Mr. du Fay. In this respect then they are entirely similar to the phosphorus of urine: perhaps even ordinary sulphur heated, and properly treated, might exhibit the same phenomena (*b*).

(*b*) I doubt whether a phosphorus could be made of sulphur without addition of quicklime or other substance, to which the vitriolic acid has a disposition to unite. For the principal cause of that slow combustion which produces phosphoric light seems to be, that the union between the acid and the phlogiston of such phosphoric substances, is weakened by the presence of some earth to which the acid has also a disposition to unite; and that the phlogiston is thereby gradually disengaged, especially when it is in contact with air, to which it is at all times strongly disposed to unite, as we may perceive from the necessary concurrence of that fluid to maintain ordinary combustion, which is only a more rapid and copious disengagement of phlogiston from the burning substances. Accordingly, if we examine the several kinds of phosphorus, we shall find that each of them consists of an acid, an earth, and phlogiston. From Mr. Margraaf's experiments we find that the Bolognian and other phosphoric stones contain a selenites, or a calcareous earth united with vitriolic acid, and that the phlogiston is given to them during calcination. The phosphorus of urine contains also an acid and phlogiston. But from the experiments of the same excellent chemist we find, that this acid is always united with a peculiar earth. The phosphorus of Homberg is a combination of ma-

In the ſecond place, as to Mr. du Fay's aſſertion, that calcareous ſtones become phoſphoric by calcination, we may obſerve, that as he did not examine chemically the ſtones he employed, and made no experiments to determine whether they contained any vitriolic acid or not, we cannot be certain that they did not contain any. For we know, that many of the ſtones which ſeem to be entirely calcareous, do however contain more or leſs of gypſeous or ſelenitic ſubſtances. Of this kind, perhaps, the ſtones employed by Mr. du Fay might be. Beſides, if we ſuppoſe that theſe ſtones contained no acid nor ſulphur, perhaps they are capable of retaining ſome of the phlogiſton of the coals in the calcination, and we may eaſily conceive that this phlogiſton alone is capable of producing a phoſphoric quality. Laſtly, we are certain, even from Mr. du Fay's experiments, that pure calcareous ſtones become much leſs luminous by calcination than thoſe which contain an acid, and are rendered phoſphoric much more difficultly.

After all that we have ſaid concerning phoſphoric ſtones, we ought to underſtand them clearly. The *phoſphorus of Baldwin* and the *phoſphorus of Homberg* are exactly ſimilar to thoſe made with the Bolognian ſtone and phoſphoric ſpars, from which they differ only in the kind of acid which they contain.

The *phoſphorus of Baldwin* is a combination of chalk with nitrous acid; and the *phoſphorus of Homberg* is a combination of quicklime with the acid of ſal ammoniac. The former is therefore a nitre with calcareous baſis, and the other a marine ſalt with calcareous baſis. They acquire the phoſphoric property by calcination, as well as the Bolognian ſtone and ſpars do, which are vitriolic ſalts with baſis of calcareous earth. Theſe two matters are not to be calcined in contact with fuel, but in crucibles. The phoſphorus of Baldwin receives its phlogiſton from the nitrous acid; chalk alſo contains ſome phlogiſton. The phoſphorus of Homberg receives its phlogiſton from the ſal ammoniac which is treated with quicklime.

As the nitrous and marine ſalts with earthy baſes are deliqueſcent, they attract the moiſture of the air after they have been dryed, and even after they have loſt ſome of their acid by calcination; for which reaſon they cannot be preſerved but in veſſels accurately cloſed, and their phoſphoric quality laſts much ſhorter time than that of ſpars. The theory of theſe two kinds of phoſphorus ſeems to be exactly the ſame as that of phoſphoric ſtones. *See* Spar.

DXXXIX. PINCHBECK. *See* Brass *and* Similor.

DXL. PITCH. (*i*)

rine acid with calcareous earth, which abſorbs phlogiſton from the burning fuel during its fuſion. The phoſphorus of Baldwin is a ſimilar combination of nitrous acid with calcareous earth; and the pyrophorus of Homberg is a combination of vitriolic acid, earth of allum, and the phlogiſton of flour, or other inflammable ſubſtance.

(*i*) Pitch. When the wood of pines, firs, and other trees, from which turpentine is obtained, is expoſed to fire in veſſels which have openings only at their bottoms, as, for inſtance, in an inverted retort, the reſinous and other juices melt out by the heat, and at the ſame time acquire an empyreumatic ſmell and taſte. This is *tar*, which being boiled, exhales much acid phlegm and eſſential oil, and becomes thick. It is then changed into *pitch*. Pitch and tar conſiſt chiefly of the reſinous, but contain alſo much of the gummy, ſaline, and earthy matter of the wood. Hence they are not much diſpoſed to unite with oils and fat; and hence too they are gradually corroded by air and moiſture, when employed to preſerve wood, and other ſubſtances; as ſhips, caſks, ſhingles,

DXLI. P I T C H (M I N E R A L). (*k*)

DLXII. P L A N T S. *See* KINGDOM (VEGETABLE).

DXLIII. P L A S T E R. *See* GYPSUM.

DXLIV. P L A T I N A. Platina is a perfect metal, analogous with the perfect metals, especially with gold, as many properties are common to both.

Although metals, from their great utility, have been always diligently searched for, yet this has remained undiscovered till lately, which is a very surprising circumstance, and which seems to prove that platina is not, like the other metals, scattered in different parts of the world, and in all climates. Platina is found in the golden mines of Spanish America, and chiefly in those of Santa Fé near Carthegena, and in the Bailliwick of Choco in Peru.

This metal was probably known to the workers of these mines long before it was brought into Europe: but as its color is not very fine, and as it is almost intractable, especially by fusion, without addition, they seem to have neglected it, considering it as some refractory mineral or marcasite: some of them, however, had attempted to melt it, and to make toys of it, as tobacco-boxes and other things of that kind; but this must certainly have been by allaying it with other metals, as we shall soon see the impossibility of their doing it otherwise.

Nevertheless, this metal continued to be so neglected, that it was entirely unknown in Europe till Don Antonio Ulloa, a Spanish mathematician, who accompanied the French academicians sent by the King of France to Peru to determine the figure of the earth by measuring a degree of the meridian, first mentioned it in the relation of his voyage, printed at Madrid in the year 1748: but he says little of it, and represents it as an intractable metallic stone, which impeded the extraction of gold from the ore when it was in a large quantity. This account was not very likely to excite the curiosity of chemists concerning a new perfect metal, and a matter so interesting and surprising as they afterwards found it to be.

But before that time, that is, in 1741, an English metallurgist, called *Wood*, who had brought from Jamaica some specimens of it, which he was informed had come from Carthagena, attended more to it, and made some good chemical trials

shingles, &c. To render them more durable, and less liable to be melted by the heat of the sun in summer, an anonymous author advises that tar should be mixed when boiling-hot with coal-dust, in such quantity as to render it thick; by which preparation, he says, tar is fixed, never runs, bends and hardens surprizingly from heat and moisture.

From two ounces of pitch, one ounce and half a scruple of resinous matter were extracted by spirit of wine. Half an ounce of empyreumatic oil separated during the digestion, and nearly half an ounce of earthy matter remained, from which water extracted nothing. The same quantity of the same pitch, boiled first in water, yielded two drams and half a scruple of gummy extract.

Eight ounces of pitch distilled in an open fire yielded two ounces one dram and a half of an acid spirit, and two ounces five drams of a fetid oil, three ounces of a shining black coal remaining in the retort. *Neuman.*

(*k*) PITCH (MINERAL). This is a fetid, black, thick, and tenacious bitumen, differing from petroleum in having a thicker consistence and a darker color. Petroleum, exposed to evaporation, deposites a substance similar to mineral pitch. It is used for the same purposes for which pitch and tar are applicable.

of it. Since that time, ſeveral chemiſts, the chief of which are M. Scheffer, of the Swediſh Academy, and Dr. Lewis, of the Royal Society of London, have very particularly examined this ſingular metal, and have publiſhed their experiments. Dr. Lewis has in ſome meaſure exhauſted this matter, in four excellent memoirs communicated to the Royal Society. Platina was, nevertheleſs, little known in France till the year 1758, when Mr. Morin, zealous for the progreſs of ſcience, collected, tranſlated into French, and publiſhed an account of all that had hitherto been done upon platina, in a work entitled, *Platina, White Gold, an eighth Metal.*

This publication excited the curioſity of French chemiſts, to whom it was a new and intereſting object; but the difficulty of obtaining a matter ſo dear prevented all of them from being able to ſatisfy their deſire of examining it. Meſſrs. Macquer and Beaumé were the only perſons who made experiments upon it, which they have publiſhed amongſt the Memoirs of the Academy for the year 1751.

About the ſame time alſo, Mr. Margraaf examined platina, and publiſhed a diſſertation concerning it.

Theſe are the only chemiſts who have examined, at leaſt, who have publiſhed their reſearches concerning this new metal But although their number be ſmall, yet their experiments are ſo numerous, made with ſuch accuracy, and in general ſo conſiſtent with each other, that by collecting and comparing them, we may acquire as certain and almoſt as extenſive knowledge of platina as of the other metals that have been known from time immemorial. This article ſhall contain the moſt general and certain reſults of the experiments made by the above-mentioned chemiſts.

Platina, a Spaniſh word, is a diminutive of *plata*, which in that language ſignifies ſilver. It is therefore called by the Spaniards *little ſilver*. This name is improper, ſince it reſembles ſilver only in being indeſtructible, and very imperfectly in its color. The name of *white gold*, given to it by ſome chemiſts, is more ſuitable; for we ſhall ſee that it reſembles gold more than any one metal reſembles any other; and hence we ſhall chiefly compare it to gold.

We do not certainly know the origin and natural hiſtory of platina. We can only aſſert, that all that we ſee in maſſes, or worked into forms, is not pure nor in its natural ſtate; for we are certain that it is unfuſible, without addition, by the moſt violent fire of our furnaces. All the platina that is found in the cabinets of curious perſons conſiſts of ſmall angular grains, the corners of which are a little rounded. It is mixed with a conſiderable quantity of ſmall black ſand, as attractable by magnets as the beſt iron, but unſoluble by acids, unfuſible, and untractable. This ſand is perfectly ſimilar to that which is found at St. Quay in Bretagne. The grains of platina are alſo frequently interſperſed with particles of ſpar and of quartz, and ſometimes with ſpangles of gold. Meſſrs. Macquer and Beaumé found a pretty large ſpangle of gold in the platina examined by them. But theſe heterogeneous matters are quite foreign to platina, and are not combined with it; for it contains nothing extraneous excepting a little gold and mercury, which latter ſubſtance it probably receives during the operations for extracting gold from the ores by means of mercury. Theſe matters may eaſily be ſeparated from the platina without decompoſing it, by waſhing and by magnets. Some chemiſts, who know

platina

platina only by name, and deny that it is a peculiar metal, have therefore, with great impropriety, advanced, that Mr. Margraaf had decomposed it, and had obtained from it gold, iron, and arsenic. The contrary appears from Mr. Margraaf's Dissertation. Mr. Margraaf only separated the heterogeneous matters which were merely mixed with platina, as other chemists have done; but he is too good a chemist to pretend that he has decomposed it: on the contrary, he does not hesitate to call it a *perfect metal*, which name is also given to it by all who understand metals.

The color of the grains of platina is metallic, white, livid, not very brilliant, intermediate betwixt the white of silver and the grey of iron. At first view they resemble large filings of iron. They are smooth, and are nearly as hard as iron; they are somewhat ductile; so that some of them may be flattened upon an anvil, while others are bruised into small pieces.

The specific gravity of platina is very great, and nearly equal to that of gold. In water it loses only something betwixt an eighteenth and a nineteenth part of its weight.

The tenacity of the parts of this metal has not been determined, because it cannot be formed into a proper figure to make the experiment. But if this quality is proportionable to the ductility and hardness of metals, we may presume, that as platina is much harder than gold, its tenacity is also greater, if all the ductility of which it seems susceptible could be given to it by art.

Platina is, like pure gold and silver, free from all smell and taste. It is unalterable by the combined action of air and water, and is no more susceptible than the other perfect metals of acquiring rust. Like them also, it is indestructible by the most violent and long continued fire: but the property which peculiarly distinguishes this metal is its infusibility by the most intense heat.

As fusion is necessary for the application of metals to use, chemists have made their utmost efforts to melt platina The most violent heat which could be raised in air-furnaces, or by the united action of several large bellows, has been applied repeatedly, and continued a long time without success. In all these trials the grains of platina remained unaltered in form and weight, and were only agglutinated to each other, nearly as sand is by exposure to violent heat, but so slightly, that by the smallest effort they were separable. Messrs. Macquer and Beaumé exposed platina during five days and five nights to the greatest heat of a glass-house furnace, which trial did only confirm the unfusibility and unalterability of platina by ordinary fires, as it was found to be only a little agglutinated, and its weight to be a little encreased; which latter phenomenon has been also observed by Mr. Margraaf. Lastly, Messrs. Macquer and Beaumé, having exposed platina to the focus of a large burning-glass, melted a little of it in a minute. It first smoked, then emitted sparks, and those parts of it melted well which were exposed to the center of the focus. These chemists carefully examined the properties of this platina. According to their memoir, the melted parts were distinguishable from the others by a brilliancy like that of silver, and by a rounded, shining, polished surface. They were easily flattened upon an anvil, and formed into very thin plates without cracking or splitting; so that these grains seemed to be much more malleable than platina in its natural state. These metals by repeated strokes of the hammer became hard and brittle, as all other metals do, particularly gold and

silver;

ſilver; and by annealing, their malleability was reſtored, as it is alſo to other metals by the ſame means. After experiments ſo certain and well authenticated, we cannot doubt that platina is truly a metal, and even a third metal, as perfect in its kind as gold and ſilver are in theirs. This propoſition will be further confirmed by the other properties of platina.

Platina reſiſts as perfectly as gold the action of the vitriolic, marine, or nitrous acids; in a word, of any pure acid, in whatever manner applied. Theſe acids, concentrated or diluted, may be boiled any length of time upon platina without diſſolving an atom of it: but a mixture of nitrous and marine acids, aqua regia, the ſolvent of gold, is alſo the ſolvent of platina. Meſſrs. Macquer and Beaumé have obſerved, that an aqua regia compoſed of equal parts of the two acids diſſolves moſt of this metal. But, however the aqua regia is made, more of it is required to diſſolve platina than gold. Theſe chemiſts employed a pound of aqua regia to diſſolve an ounce of platina. All the acid of this quantity of aqua regia was not indeed employed to diſſolve the platina, becauſe much of it was diſſipated in vapors during the operation, from the long time employed in the ſolution; and therefore if the operation had been performed in cloſe veſſels, and by diſtillation and cohobation, as Dr. Lewis did, a leſs quantity of aqua regia would have been ſufficient: but this is a matter of ſmall importance.

Aqua regia requires to be aſſiſted by the heat of a ſand-bath, and alſo a conſiderable time, to diſſolve platina well. Although the color of this metal is white, its ſolution is very yellow, even deeper than that of gold. When a ſmall quantity of platina only is diſſolved in aqua regia, or when a ſaturated ſolution is much diluted, a beautiful yellow color is produced, undiſtinguiſhable from that of a ſolution of gold: but while the aqua regia becomes more and more ſaturated with platina, its color becomes more and more intenſe, and at laſt red; but this apparent redneſs evidently proceeds from nothing but the intenſity of the yellow color; for this ſaturated ſolution is rendered yellow by dilution with water. In this circumſtance it is ſimilar to tincture of ſaffron.

The ſolution of platina in aqua regia is acid and corroſive, and from it a neutral cryſtallizable ſalt may be obtained. When the acids employed are concentrated, and when the ſolution is nearly ſaturated, a confuſed cryſtallization is formed at the bottom of the matraſs, which may be found to be a heap of very ſmall, yellow, tranſparent cryſtals. Theſe cryſtals of platina may be obtained much larger and more beautiful by evaporating the ſolution of platina with a very ſlow fire, and by cooling it very ſlowly. I found that the ſolution of platina tinged the ſkin and other animal matters with a blackiſh brown color, in certain circumſtances (in which reſpect it reſembles the ſolutions of gold, ſilver, and of mercury), and that ether mixed with this ſolution by agitation quickly ſeparates from it, and becomes tinged with a fine yellow color, preciſely as it does when it is treated in the ſame manner with a ſolution of gold. This experiment ſhews, that ether, and probably other attenuated oily matters, take platina, as they do gold, from aqua regia; and hence we may perceive another inſtance of the conformity of theſe two metals. But as ether does not acquire nearly ſo intenſe a color as the ſolution of platina, we may infer that it only receives a ſmall quantity of this metal. Beſides, the platina ſoon ſeparates ſpontaneouſly from the ether.

Platina may be precipitated from its ſolvent by fixed and volatile alkalis (*l*); and theſe precipitates are all of a yellow brick-color, when only ſo much alkali is employed as is neceſſary to ſaturate the acid of the ſolution; but are of a paler color when a ſuperabundant quantity of alkali is employed, or when they are digeſted in alkali. Theſe colors of precipitates of platina proceed from a large quantity of ſaline matters which precipitate along with them, and which ſtrongly adhere to them, and not from any calcination of this metal, or loſs of its phlogiſton. The proof of this is, that if the cryſtals or precipitates of platina be expoſed to ſtrong heat, the ſaline matters which adhere to them are expelled, the color occaſioned by them is loſt, and the platina recovers without any addition its ordinary metallic ſtate.

All the above-mentioned phenomena exhibited by platina treated with acids and alkalis are ſimilar to thoſe which gold exhibits in ſimilar circumſtances: but platina has alſo in this reſpect ſome peculiar properties by which it differs from gold. 1. The ſolution of platina acquires a deeper color than that of gold. 2. The precipitate of platina made by volatile alkali does not fulminate as that of gold does. 3. Tin does not produce from the ſolution of platina a purple precipitate, capable of tinging glaſs, as it does from a ſolution of gold.

Neither nitre, which quickly and effectually calcines all imperfect metals; nor corroſive ſublimate, the acid of which, being very much concentrated, acts upon almoſt all metals; nor any other neutral ſalt, could occaſion the ſmalleſt alteration upon platina or upon gold.

This ſingular metal reſiſts, as well as gold does, the action of ſulphur, which ſo powerfully diſſolves other metals. From Dr. Lewis's experiments we find, that liver of ſulphur is capable of diſſolving platina, as it does alſo gold, by fuſion. Mr. Margraaf's experiments leave this matter uncertain: but if, as we have reaſon to believe, liver of ſulphur does diſſolve platina, this is another inſtance of the conformity of this metal with gold.

Almoſt all metallic ſubſtances are capable of ſeparating platina from aqua regia, as they alſo ſeparate gold. Platina precipitated by theſe ſubſtances has its metallic appearance. In this reſpect it conforms with a general rule, that metals precipitated by other metals have their metallic appearance. *See* PRECIPITATION.

Mr. Margraaf relates, in his Memoir, a great number of experiments which he made to diſcover the effects of mixing a ſolution of platina with other metallic ſolutions, and alſo of digeſting pure platina with theſe ſolutions and other ſaline ſubſtances. Theſe experiments furniſhed many curious and intereſting facts; but as ſeveral of them do not ſeem to be conſiſtent with the eſſential and aſcertained properties of platina, nor even with ſimilar experiments made by other chemiſts, we have reaſon to believe that theſe ſingularities obſerved by this able chemiſt proceeded from ſome extraneous matters with which his platina was

(*l*) Mr. Margraaf mentions a very ſingular fact concerning the precipitation of platina by alkalis; namely, that although vegetable fixed alkali, and even volatile alkali, precipitated this metal from aqua regia; yet the mineral alkali, though in other inſtances equal in power of union to the former alkali, and ſuperior to the latter, produced no precipitation, even when ſo much of it was added as to ſaturate the acid, nor even diſturbed the tranſparency of the liquor.

allayed. From moſt of theſe experiments, as, for inſtance, from the yellow flowers obtained by ſubliming platina with ſal ammoniac, and from the blue precipitate formed by mixing his ſolution of platina with a lixivium of Pruſſian blue, we may conclude, that iron was the metal with which his platina was allayed, as he himſelf ſays.

Platina, like gold, is capable of being allayed with all metals, and in theſe allays exhibits intereſting phenomena. Dr. Lewis has examined theſe allays more carefully and fully than any other perſon. As we have ſaid nothing of it under the article ALLAY, we ſhall ſummarily mention here what Dr. Lewis has obſerved on this ſubject.

Platina, although very unfuſible when alone, may however be fuſed along with other metals with which it is capable of combining. Equal parts of gold and platina may be melted in a violent fire, and the allay which is formed may be eaſily poured into an ingot mould. It is whitiſh, hard, and may be broken by a violent blow. Neverthele ſs, when it has been well annealed, it is capable of conſiderable extenſion under the hammer. One part of platina and four parts of gold may be melted and allayed with a much leſs fire than is requiſite in the preceding experiment. This allay is ſo ductile, that it may be extended into very thin plates without being broken, or even ſplit at the edges. Dr. Lewis obſerved a remarkable circumſtance concerning this allay, namely, that the platina, which was $\frac{1}{5}$ of the whole maſs, rendered the gold no paler than guineas are, which contain only $\frac{1}{12}$ of ſilver.

Silver and platina may be melted and allayed together in equal parts with a very violent fire. The allay which is formed is much harder and darker-colored than ſilver, and of a large grain, although it preſerves ſome ductility. Theſe qualities are leſs ſenſible when one part of platina is added to ſeven parts of ſilver: but this allay is ſtill coarſer-grained and leſs white than ſilver. This coarſeneſs of grain ſhews an imperfect union; and indeed ſilver and platina do not ſeem to unite very intimately; for Dr. Lewis obſerves, that when the allay of theſe two metals was left after fuſion in the crucible, a conſiderable part of the platina was ſeparated and ſunk to the bottom. The platina did not appear to communicate any good quality to the ſilver, excepting a greater hardneſs.

Copper ſeems to be moſt improved by being allayed with platina. When indeed a large proportion of platina is added to copper, as equal parts or two-thirds, the allay is hard, brittle, and coarſe: but when a leſs quantity of platina is added, as from $\frac{1}{6}$ to $\frac{1}{25}$, or even leſs, a golden-colored copper is produced, very malleable, harder, ſuſceptible of a finer poliſh, ſmoother-grained, and much leſs ſubject to calcination and ruſt than pure copper.

Dr. Lewis was not able to fuſe forged iron with platina, which is not ſurprizing, when we conſider the refractory qualities of theſe two metals: but he allayed platina with caſt-iron, by throwing one part of platina to four parts or more of the iron when it was juſt beginning to flow. This allay was much harder, and much leſs ſubject to ruſt, than pure iron. It was ſuſceptible of a very fine poliſh.

Platina may be melted with tin in all proportions from equal parts of the two metals to twenty-four parts of tin. This allay was obſerved to be ſo much harder, more brittle, more dark-colored, and coarſer, as the proportion of the

platina

platina was larger. No advantage ſeemed to be acquirable by this allay. Lead alſo may be allayed in different proportions with platina, nearly as tin may, with this difference, that a much greater fire is neceſſary for the formation of this latter allay, particularly when the quantity of platina is great. The metal reſulting from it has a dark color, ſomewhat approaching to a purple or violet, or it eaſily acquires theſe colors when expoſed to the air. When the two metals fuſed together are left in a crucible to cool, a conſiderable part of the platina ſeparates and falls to the bottom, in the ſame manner as it does from the allay of ſilver.

From Dr. Lewis's experiments platina appears to be capable of amalgamating with mercury, but difficultly, and by a very long trituration with water, as, for inſtance, during a week.

If mercury be triturated with an allay of gold and platina, it ſeizes the gold, and does not touch the platina. Dr. Lewis propoſes this amalgamation as a method of ſeparating theſe two metals; and it is that which is employed in the ores of Peru, in which gold and platina are mixed together: but we do not yet know whether this ſeparation be perfectly complete.

Platina may be allayed with biſmuth nearly as with lead, and in a ſimilar manner ſeparates from the biſmuth after fuſion. It gives to biſmuth alſo, as it does to lead, the property of acquiring, by expoſure to air, violet, purple, or blue colors. This allay is always very brittle.

Of all metallic matters zinc may be moſt eaſily allayed with platina, and moſt effectually diſſolved by fuſion. Dr. Lewis obſerved, that theſe allays did not appear very different from pure zinc; but that when the proportion of platina is conſiderable, their grain is cloſer, their color leſs clear, and more bluiſh than of zinc. They do not tarniſh, nor change colors, by expoſure to air. Laſtly, they are harder than zinc, and have not the ſemi-malleability of this ſemi-metal.

With regulus of antimony platina formed a darker and harder compound than the pure regulus.

Dr. Lewis has combined platina at the ſame time with two metallic matters, ſuch as with braſs compoſed of copper and zinc, and with bronze compoſed of copper and tin. The moſt ſingular phenomenon of this latter allay was, that the copper and tin acting conjointly upon the platina was capable of diſſolving more of it than they both could do ſeparately. This allay was hard and capable of receiving a fine poliſh, but is ſubject to tarniſh, which ſeems to happen to all the allays of tin or of lead with platina.

Equal parts of platina and braſs formed a compound very hard and very brittle, capable of receiving a very fine poliſh, and not ſubject to tarniſh. It might therefore be employed for ſpeculums of teleſcopes, and would be much preferable to thoſe now uſed, all which have the great diſadvantage of tarniſhing by expoſure to air, and even very quickly.

Dr. Lewis does not mention the effects of allaying platina with arſenic; but Mr. Scheffer affirms, that if only a twentieth part of arſenic be added to platina when red-hot in a crucible, theſe two ſubſtances will be perfectly fuſed, and will form a brittle, grey maſs. This remarkable experiment requires confirmation: for Mr. Margraaf having alſo treated theſe two matters together, did not perceive any ſuch action of arſenic upon platina. From one of his experiments

we find, that having exposed to a violent fire during an hour a mixture of an ounce of platina with a fusible glass composed of eight ounces of minium, two ounces of flints, and one ounce of white arsenic, he obtained a regulus of platina, well united and fused, which weighed an ounce and thirty-two grains, the surface of which was smooth, white and shining, and the internal parts grey, but which nevertheless appeared sufficiently white when it was filed.

The cupellation of platina was one of the most important experiments to be made; because if this operation succeeded perfectly, we might thereby obtain compact and malleable masses of pure platina, in the same state as a metal which had been well fused, and of which all sorts of utensils might be made, if not by casting it, at least by forging. All the chemists who have examined this metal, and particularly Dr. Lewis, have used their utmost endeavours to cupel it well. But although they have used every expedient to apply the strongest heat, they have not perfectly succeeded. The scorification proceeds well at the beginning of the operation, as when gold and silver are cupelled: but the cupellation afterwards becomes more and more difficult; because, as the quantity of lead diminishes, the matter becomes less and less fusible, and at last ceases to be fluid, notwithstanding the most violent heat; and also because, when the quantity of platina is greater than that of the lead, this latter metal is protected, and is not converted into litharge. Hence the regulus obtained is always dark-colored, rough, adhering to the cupel, brittle, and weighing more than the platina originally employed, from the lead which remains united with it. Messrs. Macquer and Beaumé appear nevertheless to have carried this experiment further than any other chemists, as they kept the matter exposed to a violent fire during a longer time, that is, about fifty hours successively; therefore, although their platina was tarnished and rough on its surface, it was internally white and shining, easily separable from the cupel, and a little diminished in weight, a certain proof that no lead remained in it. This platina was also ductile, and capable of extension under the hammer. Cupellation is therefore a certain method of applying platina to use, and of forming it into utensils.

The sciences, commerce, and arts must receive great advantages from the application of a new perfect metal to useful purposes, which to the fixity and indestructibility of gold unites a hardness and solidity almost equal to those of iron; which is unalterable by the action of water and air; is not subject to rust; and resists as well as glass or earthen vessels all salts, even aqua fortis and other pure acids. We regret, that although large quantities of it are found in America, it is so exceedingly rare here.

The cause of this great scarcity of platina is, that the Spanish Ministry have prohibited the sale of it, or the extraction of it from the mines. These prohibitions were certainly from good motives and wise intentions; for this metal was no sooner known than it was employed for the adulteration of gold, for which purpose it is very fit, as it sustains all the ordinary trials of gold, has the same specific gravity, and renders gold much less pale than silver. The use of a metal with which frauds so prejudicial might be committed with impunity was necessarily interdicted: but since the best chemists of Europe have examined platina, they have published certain and easy methods by which the smallest quantity of platina mixed with gold may be discovered, and by which these metals

metals may be ſeparated, in whatever proportion they may happen to be united. Theſe methods may be ſeen in the Memoirs of the chemiſts who have examined this matter. We ſhall here relate only one of the moſt convenient and leaſt troubleſome. It is founded on a property which gold has, and not platina, of being capable of precipitation from aqua regia by martial vitriol; and upon a property which platina has, and not gold, of being capable of precipitation from aqua regia by ſal ammoniac. When therefore we would diſcover if gold be allayed with platina, let it be diſſolved in aqua regia, and to this ſolution, which will contain both metals, let ſome ſal ammoniac diſſolved in water be added, upon which the platina will be precipitated in form of a brick-colored ſediment. If, on the other ſide, we would know if platina contained any gold, let this platina be diſſolved in aqua regia, and to the ſolution add a ſolution of martial vitriol in water, upon which the liquor will become turbid, and the gold will form a precipitate which may be eaſily ſeparated by decanting and filtrating the liquor.

We may then affirm, that the reaſons which induced the Spaniſh Miniſtry to interdict the uſe of platina no longer ſubſiſt; and we hope that when they are once convinced of this, ſociety ſhall no longer be deprived of a ſubſtance which may be ſo advantageous to them, and which may be a new ſource of wealth to the Crown of Spain, the ſole proprietor of this precious treaſure.

DXLV. PLUMBUM CORNEUM. This is a combination of lead with marine acid. It is a metallic ſalt which may be made by combining directly lead with that acid: but this proceſs is not much uſed, becauſe others are more convenient. For inſtance, by pouring ſome marine acid, or the ſolution of a ſalt containing it, into a ſolution of lead made by the nitrous acid, we obtain a plumbum corneum, which falls down to the bottom of the veſſel, if the liquor does not contain too much water. A ſimilar combination may be made by diſtilling calxes of lead, as minium, for inſtance, with ſal ammoniac. The lead diſengages the volatile alkali of this ſalt, and unites with its acid, which is the ſame as that of common ſalt.

Lead united with marine acid has ſome reſemblance to luna cornea, which is a combination of ſilver with the ſame acid; and hence has been called plumbum corneum. Like the luna cornea, it is ſemi-volatile and cryſtallizable, but is infinitely more ſoluble in water. This combination is not uſed in the arts, and little in chemiſtry. *See* LEAD.

DXLVI. POMPHOLIX. This is one of the names given to the flowers of zinc ſublimed during the deflagration of this ſemi-metal. *See* FLOWERS *of* ZINC *and* ZINC.

DXLVII. PORCELAIN. Porcelain is the moſt beautiful and fineſt of all earthen wares. All earthen wares which are white and ſemi-tranſparent are generally called porcelains: but amongſt theſe ſo great differences may be obſerved, that notwithſtanding the ſimilarity of their external appearance, yet when they are examined chemically, they cannot be conſidered as matters of the ſame kind. Theſe differences are ſo evident, that even perſons who are not connoiſſeurs in this way prefer much the porcelain of ſome countries to that of others.

As the ſeveral kinds of porcelain differ ſo much from each other, no general proceſs can be given for making it. We ought therefore to confine ourſelves

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to describe and consider the manufacture of some particular porcelain, remarkable for its excellence and beauty. But this also is almost impracticable; because in all the manufactories where it is made, both in France and other countries, the ingredients and method of preparation employed are carefully concealed. Nevertheless, we have a general knowledge of the principal operations of this manufacture, which we shall here deliver; and that we may supply the details which we cannot describe, we shall give our opinion concerning the qualities which the best porcelain ought to have. This seems to be necessary, as the manufacture of porcelain is an object more attended to than ever; and as many persons, otherwise intelligent, talk and judge of it without having any precise notions on the subject.

The art of making porcelain is one of those in which Europe has been excelled by oriental nations. The first porcelain that was seen in Europe was brought from Japan and China. The whiteness, transparency, fineness, neatness, elegance, and even the magnificence of this pottery, which soon became the ornament of sumptuous tables, did not fail to excite the admiration and industry of Europeans. I shall not here relate the histories of the several attempts made in Europe to imitate the oriental porcelain, as most of them are unknown, and would lead us too far from the subject. I shall only say, that in different parts of Europe, earthen wares have been made so like the oriental that they have acquired the name of porcelain. Neither shall I inquire into the æra of the establishment of the several manufactures of porcelain in Europe. I shall only say, that I believe the first European porcelains were made in Saxony and in France; and afterwards in England, Germany, and Italy. But as all these were different from the Japanese, so each of them had its peculiar character.

We now proceed to determine the quality of the principal porcelains, namely, those of Japan or of China, of Saxony and of France.

The illustrious Reaumur first attended to this object, and communicated his researches in two Memoirs before the Academy of Sciences in 1727 and 1729. This great experimental philosopher took the best method of arriving at a thorough knowledge of the subject; and although he was mistaken in some points, and altho' he neglected to consider some of the essential qualities requisite to constitute good porcelain, he is nevertheless the first person who published any distinct notions upon the subject. He did not satisfy himself with considering the external appearance, the painting and gilding, which are only ornaments not essential to the porcelain, but he endeavored to examine it internally: And having broken pieces of the Japanese, Saxon, and French porcelains, he examined the difference of their *grains* (which name is given to their internal structure). The grain of the Japanese porcelain appeared to him to be fine, close, compact, moderately smooth, and somewhat shining. The grain of the Saxon porcelain was found to be still more compact, not granulous, smooth, shining like enamel. Lastly, the porcelain of St. Cloud had a grain much less close and fine than that of Japan, not, or but little shining, and resembling the grain of sugar.

From these first observations Mr. Reaumur perceived that porcelains differed considerably. That he might examine them further, he exposed them to a violent heat. More essential differences than those of the grain appeared upon this

this trial; for the Japanese porcelain was unaltered by the fire, and all the European were melted, as Mr. Reaumur says.

This essential difference betwixt the Japanese and European porcelains suggested to Mr. Reaumur a very ingenious thought, and in many respects true, concerning the nature of porcelain in general. As all porcelains somewhat resemble glass in consistence and transparency, tho' they are less compact and much less transparent, Mr. Reaumur considered them as *semi-vitrifications*. But every substance may appear, and may actually be in a semi-vitrified state in two manners: for, first, it may be entirely composed of vitrifiable or fusible matters; and in this case, by exposing it to the action of fire, it will be actually melted or vitrified, if the heat be sufficiently strong and long-continued. But as this change is not made instantly, especially when the heat is not very violent, and as it passes through different stages or degrees, which may be more easily observed as the heat is better managed; hence, by stopping in proper time the application of heat to porcelain made in this manner, we may obtain it in an intermediate state betwixt those of crude earths and of completely vitrified substances; and also possessed of the semi-transparency and of the other sensible qualities of porcelain. We know also, that if such porcelain be exposed to a stronger degree of fire, it will then be completely fused and entirely vitrified. But most of the European porcelains have this fusibility, from which Mr. Reaumur concludes, that their composition is founded upon the above-mentioned principle.

In the second place, a paste of porcelain may be composed of fusible and vitrifiable matter, mixed with a certain proportion of another matter which is absolutely unfusible in the fires of our furnaces. We may easily perceive, that if such a mixture be exposed to a heat sufficient to melt entirely the vitrifiable ingredient, that this matter will actually melt; but as it is intermixed with another matter which does not melt, and which consequently preserves its consistency and opacity, the whole must form a compound partly opake and partly transparent; or rather a semi-transparent mass; that is, a semi-vitrified substance, or porcelain, but of a kind very different from the former; for as the fusible part of this latter has produced all its effect, and as it has been as much fused as it can be during the baking of the porcelain, the compound may be exposed a second time to a more violent fire without approaching nearer to a compleat vitrification, or without departing from its state of porcelain. But as oriental porcelain has precisely these appearances and properties, Mr. Reaumur concludes with reason, that it is composed upon this principle; and he afterwards confirmed his opinion by undeniable facts.

Father *Entrecolles*, missionary at China, had sent from thence a summary description of the process by which the inhabitants of that country make their porcelain; and also a small quantity of the materials which they employ in its composition. He said that the Chinese composed their porcelain of two ingredients, one of which is a hard stone or rock, called by them *petuntse*, which they carefully grind to a very fine powder; and the other, called by them *kaolin*, is a white, earthy substance, which they mix intimately with the ground petuntse. Mr. Reaumur examined both these matters, and having exposed them separately to a violent fire, he discovered that the petuntse had fused without addition, and that the kaolin had given no sign of fusibility. He afterwards

afterwards mixed these matters, and formed cakes of them, which by baking were converted into porcelain similar to that of China. Mr. Reaumur easily found that the petuntse of the Chinese was a hard stone of the kind called vitrifiable, but infinitely more fusible than any of these which were known in Europe; and that the kaolin was a talky matter, reduced to very fine powder (*m*). From that time he hoped to make a porcelain of the same kind as the Chinese with materials found in France. Whether he could not find any materials equal to those of China, particularly that material analogous to the petuntse of the Chinese, or because other occupations prevented the continuance of his researches, we do not know; but we find, from his second Memoir upon porcelain, that he afterwards attempted to make an artificial petuntse, by mixing our vitrifiable stones with salts capable of rendering them fusible, or even by substituting for it glass ready formed, and by adding to these such substances as he thought might be substituted for kaolin. But he probably found he could not execute these intentions, for he did not resume this subject from the year 1729 to 1739,

(*m*) The *petuntse* is improperly ranked amongst the class of earths called vitrifiable, because it is fusible without addition, and because it is not hard enough to elicit sparks from steel; whereas the vitrifiable or siliceous earths are unfusible by fire, unless they contain some metallic mixture, and are very hard. Authors have not described very distinctly the petuntse; some believing it to be an alkaline spar, and others the rhomboidal quartz, called *feldtspar*. But from the later accounts, and from a knowledge of some experiments that have been made successfully concerning porcelain, I believe that the petuntse is different from both these substances, and that it is a white opake fluor. At least I have seen excellent porcelain made with such a fluor together with a white argillaceous earth. The texture of this fluor was laminated, its figure was indeterminate, it was rendered luminous in the dark by friction, it was fusible by violent heat, it was not sufficiently hard to elicit sparks from steel, and it was indissoluble by acids. It seems to be of the same kind as the Bolognian stone, and the white heavy fluors, which, as Mr. Margraaf found, are capable of acquiring by calcination with inflammable matter the property of absorbing light. *See* PHOSPHORIC STONES. Mr. Scheffer's examination of Chinese petuntse, published in the Swed. Trans. 1753, corresponds with the above account, excepting that his specimen appears to have had a greater transparency than the fluor above described, and to resemble the lapis specularis, which also possesses the phosphoric property of the Bolognian stone, and contains, according to Mr. Margraaf's experiments, nearly the same principles as that stone and the heavy white fluors above described. *See* PHOSPHORIC STONES. I do not, however, mean to affirm that no porcelain can be made without such a fluor. I am inclined to believe that porcelains may be made of other materials besides a clay or kaolin, and a white fluor or petuntse. One of the ingredients of the Saxon porcelain is a beautiful white stone, which is not fusible by a most violent heat. See Mr. D'Arcet's Memoir sur l'Action d'un Feu Violent, &c. Mem. de l'Acad. des Sc. 1766. Pure clays singly, or mixed with finely-ground siliceous earth, acquire by violent heat the hardness and all the properties, excepting the semi-transparency, of porcelain.

The *kaolin* of the Chinese is a white argillaceous earth, sometimes intermixed with particles of mica, and, as Mr. Bomare affirms, sometimes with particles of quartz and of calcareous earth. But the quantity of the last substance must be very small, as it would render the argillaceous earth fusible, and consequently unfit for the purpose of a kaolin. Mr. Guettard, who has written a Memoir upon the ingredients of Porcelain (Mem. of the Acad. of Sciences, 1765) describes the kaolin as a white argillaceous earth without any calcareous mixture. Probably the calcareous particles found in the specimen analised by Mr. Bomare, and perhaps also the particles of quartz and of mica, are not necessary and constant parts of kaolin.

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when he gave a proceſs for converting common glaſs to a ſingular kind of porcelain, to which he has given his name, and of which we ſhall treat in the following article.

Although Mr. Reaumur has not exhauſted entirely this ſubject, he has ſurmounted many difficulties, and has given juſt notions concerning it: In a word, he has opened the road for all thoſe who afterwards engaged in this purſuit, and has therefore a right to ſhare the honor of the important diſcoveries which have been ſince made by others.

But as a perſon who firſt unravels ſo intricate and hidden a matter as the manufacture of porcelain, can ſcarcely diſcover every thing concerning his ſubject, ſo Mr. Reaumur has been miſtaken, or rather miſled in two important points. His firſt error concerns the Saxon porcelain, which he confounds with the other fuſible porcelains made in Europe. I do not know whether formerly a porcelain was made in Saxony, compoſed entirely of fuſible or vitrifiable materials, the vitrification of which was ſtopt in proper time. Poſſibly this was the firſt kind of porcelain made in that country, and which Mr. Reaumur had examined. But I am certain that I have never ſeen any ſuch Saxon porcelain, and that all of that country which I have examined was capable of reſiſting the moſt violent fires without fuſion, as well, at leaſt, as thoſe of China and Japan. Mr. Reaumur might have been miſled by the appearance of the internal texture of this porcelain. For when a piece of it is broken, its internal ſurface does not appear granulous, but compact, uniform, ſmooth, ſhining, and much reſembling white enamel. But this appearance, ſo far from ſhewing that Saxon porcelain is a fuſed or vitrified ſubſtance, proves that it is not entirely compoſed of fuſible matters. All who have conſidered attentively this ſubject know that the internal ſurface of the moſt fuſible porcelains is alſo the leaſt denſe and leaſt compact: the reaſon of which is, that no vitreous matter can be ſmooth and denſe internally, unleſs it has been completely fuſed. But if the denſity and ſhining appearance of the internal ſurface of the Saxon porcelain were only the effects of the fuſion of a vitreous matter, how could we conceive that veſſels formed of that matter ſhould have ſuſtained the neceſſary fuſion for giving this denſity and ſhining appearance, without having entirely loſt their ſhape? The impoſſibility of this is evident to any perſons who have been converſant in theſe matters, and in the fuſion of glaſs.

This quality of the Saxon porcelain muſt therefore proceed from another cauſe. It does indeed contain, as every porcelain does, particularly thoſe of China and Japan, a fuſible ſubſtance, which has been even completely fuſed during the baking. Its denſity alſo and its internal luſtre proceed chiefly from this fuſed matter; but we are alſo certain that it contains a large quantity of a ſubſtance abſolutely unfuſible, from which it receives its admirable whiteneſs, its firmneſs and ſolidity, during the baking; in a word, which ſupplies the place of the oriental kaolin, and which has the property of contracting its dimenſions conſiderably while it incorporates with the fuſible ſubſtance. If it be ſubjected to the moſt deciſive trial, namely, the action of a violent fire, capable of melting every porcelain compoſed of fuſible matters alone, I affirm, after many experiments, that it cannot be fuſed, unleſs by a fire capable alſo of melting the beſt Japaneſe porcelain. The Saxon porcelain is therefore not to be confounded with thoſe which are vitreous and fuſible, but is in its kind

as excellent as that of Japan, and perhaps superior, as we shall see when we enumerate the qualities which constitute the excellence of porcelain. The subject of Mr. Reaumur's second error, or, at least, that which he has not sufficiently explained, is the *kaolin* of China. According to him, this matter is a fine talky powder, from the mixture of which with petuntse, the oriental porcelain is formed. Possibly a very finely-ground talky substance mixed with petuntse might form a porcelain similar to the oriental; but persons acquainted with the manufacture of any porcelain, must perceive the impossibility of forming vessels, unless the paste of which they are made be so ductile and tenacious, that it may be worked upon a potter's lathe, or at least that it may be moulded. But talks or any kinds of stones, however finely ground, cannot acquire the requisite tenacity, which clays only, of all known earthy substances, possess. The Chinese porcelain vessels evidently appear to be turned upon the lathe, since they retain the marks of it; hence they must have been formed of a very tenacious paste, and consequently the kaolin is not a purely talky matter, but is mixed with clay; or else the petuntse and kaolin are not, as Mr. Reaumur supposes, the only ingredients of the paste of which Chinese porcelain is formed, but a sufficient quantity of some binding matter, unknown to father d'Entrecolles and Mr. Reaumur, must be also added.

Although, since Mr. Reaumur, no scientific person has written concerning porcelain, many have attempted to make it. Manufactures have been established in almost all the states of Europe. Besides that of Saxony, which has been long established, porcelain is also made at Vienna, at Frankendal, and lately in the neighbourhood of Berlin. All these German porcelains are similar to the Saxon, and are made of materials of the same kind, although they differ somewhat from each other. England and Italy also have their porcelains, the chief of which are those of Chelsea and of Naples. Mr. de la Condamine, in his last journey into Italy, visited a manufacture of porcelain established at Florence by the Marquis de Ginori, then governor of Leghorn. Mr. de la Condamine observed particularly the large size of some pieces of this porcelain. He says he saw statues and groupes half as large as nature, modelled from some of the finest antiques. The furnaces in which the porcelain was baked were constructed with much art, and lined with bricks made of the porcelain materials. The paste of this porcelain is very beautiful; and from the grain of broken pieces of it, it appears to have all the qualities of the best Chinese porcelain. A whiter glazing would be desirable, which they might probably attain, if the Marquis Ginori was not determined to use those materials only which were found in that country.

But in no state of Europe have such attempts been made to discover porcelain, or so many manufactures of it been established, as in France. Before even Mr. Reaumur had published on this subject, porcelain was made at Saint Cloud, and in the suburb of St. Antoine at Paris, which was of the vitreous and fusible kind, but considerably beautiful. Since that time, considerable manufactures of it have been established at Chantilly, at Villeroi, and at Orleans; the porcelains of which have a distinguished merit. But certainly the admirable works produced in the King's manufacture at Sevres does most honor to France. This porcelain holds at present the first rank, from its shining white, its beautiful glazing, and colored grounds, in which no porcelain has ever

ever equalled it. The magnificence of the gilding, the regularity and elegance of its forms, surpass every thing of the kind. In the painting and sculpture much genius and talents are displayed We cannot commend this work more, than by mentioning that Messrs. Bachelier and Falconet preside and direct it. Lastly, as all the operations of this truly great and royal establishment are directed by men of known capacity, assisted by philosophical and chemical researches, this manufacture is upon the point of producing porcelain capable of emulating or equalling the most perfect and most solid works of this kind (*n*). We ought also to give due praises to several of our contemporaries and countrymen, who have distinguished themselves in their attempts in this way. Mr. Guettard, physician of the Faculty at Paris, an able naturalist of the Academy of Sciences, and who has particularly applied himself to the study of earths and fossils, seems to have been one of the first who, since Mr. Reaumur, pretended to have found in France a kaolin and petuntse of the same nature as the Chinese.

Mr. Guettard has lately published an account of his discoveries on this subject, in the Memoirs of the Academy of Sciences for the year 1765. The kaolin which he employed was a white argillaceous earth, filled with mica, which he found in the neighbourhood of Alençon; and his petuntse is a hard, quartzose grit stone (*o*), found abundantly in the same country, with which the streets of Alençon are paved. We also know that Mr. Guettard had begun to make his experiments on porcelain with these materials in the year 1751, together with the late Duke of Orleans, to whom he was attached. The Count de Lauraguais, of the Academy of Sciences, who has acquired a distinguished reputation in chemistry by several excellent discoveries, on the acetous ether, on the solution of sulphur by spirit of wine, on the inflammation and crystallization of radical vinegar, &c. engaged in the pursuit of porcelain for several years with uncommon ardor and constancy. He spared no trouble nor expence to attain his purpose, which was to make porcelain equal in all respects to that of China and Japan. He shewed some pieces made by him, in the year 1766, to the Members of the Academy of Sciences. The persons appointed by them to examine it gave their opinion, that of all the porcelains made in this country, that of the Count de Lauraguais most resembled the

(*n*) The porcelain of the King of France's manufacture at Sévres deserves much of the magnificent encomium here given to it, for the beautiful whiteness of its ground; for the neatness of execution; and especially for the good taste shewn in the modelling, designing, and decorations. But it is much inferior to the Saxon or to the oriental porcelain, in the intrinsic excellencies, strength, and property of resisting quick changes of heat and cold. It is a porcelain of the inferior kind, that is, a semi-vitrified substance, composed of ingredients all of which are fusible. Accordingly, in a strong heat it may be vitrified. The author of the Dictionary shews his respect to the Royal proprietor of this manufactory by not mentioning the defects of the porcelain of Sévres; but from his expectations of that porcelain being further improved and rendered equal to the most perfect works of this kind, we may presume that he was not ignorant of these defects.

(*o*) The above-described fluor or petuntse is frequently found intermixed with quartz and with mica, forming compound stones; which, if the quantity of the fluor predominates, and if, at the same time, the other ingredients contain no metallic tinge, may be employed in the manufacture of porcelain. Probably the stone found near Alençon is of the kind here described.

 porcelain

porcelain of China and Japan in solidity, grain, and unfusibility. It were to be wished that it possessed equally the other qualities essential to the excellence of porcelain, namely, the whiteness and lustre observable in the ancient Japanese porcelain (*p*).

We shall not here particularly examine the qualities of the several porcelains now known. We shall only shew what those qualities are which constitute the perfection of porcelain. We must first carefully distinguish the qualities which only contribute to beauty and external appearance, from the intrinsic and essential properties in which the goodness and solidity of porcelain consist. All persons who have made experiments in this way have soon discovered the possibility of making compounds very white, beautifully semi-transparent, and covered with a shining glazing, but which cannot be worked for want of tenacity, are not sufficiently compact, are essentially fusible, are subject to break by sudden application of heat and cold; and, lastly, the glazing of which cracks, becomes rough, and consequently loses its lustre by use, because it is too soft.

On the other side, we shall also find it not difficult to compose very tenacious pastes, which shall be capable of being easily worked and well baked, which in the baking shall acquire the desirable hardness and density, which are unfusible, and capable of sustaining very well the sudden change of heat and cold; and, in a word, which shall have all the qualities of the most excellent porcelain, excepting whiteness and beauty. We shall soon see that the materials fit for the composition of such porcelains may be found abundantly in every country. The only difficulty then in this inquiry concerning porcelain is, to unite beauty and goodness in one composition. I acknowledge that nature seems to be very sparing of materials fit for this purpose, and therefore perfect porcelain will always be a dear and valuable commodity.

Many will be surprized when I affirm, that before we had any knowledge of oriental porcelain, and from time immemorial, porcelain was made here equal in goodness and in essential qualities, and was universally used and even sold very cheap. For those potteries which we call *grais* or *stone-ware* are not of modern invention, and have all the essential qualities of the best Japanese. For if we except whiteness, on which alone the semi-transparency depends, and compare all the properties of Japanese porcelain with those of our stone-ware, no difference can be found betwixt them. The same grain appears internally in both; the same sound is produced by striking them when properly suspended; the same density; the same hardness, by which they strike fire with steel; the same faculty of sustaining the heat of boiling liquors without breaking, and the same unfusibility in fire, are observable. Lastly, if the earths of which stone-ware is made were free from heterogeneous coloring matters, which prevent their whiteness and semi-transparency; if vessels were carefully formed; if all the proper attentions were given; and if these vessels were cover-

(*p*) The porcelain made by that ingenious and scientific nobleman is said to have possessed the intrinsic excellencies of porcelain, as eminently, at least, as even the Saxon or oriental. A gentleman of undoubted veracity has assured me, that when the Count de Lauraguais was a few years ago in England, he saw him heat a piece of his porcelain till it was red-hot, and then throw it into cold water, without breaking or cracking it.

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ed over with a fine glazing; they would be as perfect porcelain as that of Japan. The most perfect porcelain, therefore, is nothing else than a fine white stone-ware. (q)

Earths of this kind are probably more rare in Europe than in Japan and China. And probably also the want of these earths was the cause that the first makers of porcelain in this country confined themselves to an external imitation, by employing nothing but vitrifiable matters with fusible salts and a small quantity of white earth, from which fusible and vitreous porcelains were composed, which might be called *false porcelains*. But things are much changed since these first attempts. Besides the discoveries of the Count de Lauraguais and of Mr. Guettard, genuine white porcelains have been made a long time ago in Germany, especially in Saxony and at Frankendal. The new porcelain, a trial of which is just finished at the King's manufacture, is of this kind. (r)

These porcelains are not inferior in any respect to the oriental; they are even much superior in beauty and whiteness to the modern oriental porcelain, which has much degenerated in these respects; they seem even to excel the oriental in the most valuable quality of porcelain, namely, the property of sustaining the sudden change of heat and cold. We cannot judge of the quality of porcelain by a slight trial: for so many circumstances concur to make a piece of porcelain capable or incapable of sustaining the sudden application of heat and of cold, that if at the same time boiling water be poured into two vessels, one of which is good porcelain and the other bad, the former may possibly break, and the latter remain entire: the only true method of discovering good porcelain in this respect is, to examine several pieces of it which are daily used, for instance, a set of coffee-cups. But I have observed that in many such pieces of oriental porcelain, which have been long and daily used, cracks in the direction of their height may be always perceived, which are never seen in the good European porcelains.

Every one talks of porcelain, and yet few are connoisseurs of it. None can be considered as such but those who have long made it an object of their inquiries. That the ancient Japanese porcelain is the most perfect, is a general opinion. This porcelain is indeed very beautiful, and we must also acknowledge that its quality is excellent. It has been our model, and has long been the object of our admiration and emulation; but which we have been never able to equal, and which many persons believe never can be equalled. Some persons even decry the Saxon porcelain for a quality which really gives it a superiority to the Japanese, namely, the greater smoothness, lustre, and less granulous appearance of its internal surface than the oriental. The resemblance of this

(q) The French stone ware, or *potterie de grais*, is formed of a whitish clay, in which a good deal of fine white sandy particles are intermixed. The English *stone-ware* is composed of tobacco-pipe clay and ground flints. This ware, when sufficiently burnt, has, as well as the French, the qualities of porcelain which the author calls essential, namely, strength, hardness, the property of sustaining the heat of boiling water, and unfusibility. *See* POTTERY.

(r) I have nevertheless seen several pieces of the porcelain of Sêvres, lately brought from thence, which were not of the kind called by the author *genuine*, but which had the properties and defects mentioned in the above note (n).

surface

surface to that of glass has evidently suggested this notion; and it would be well founded, if the density and lustre of this porcelain proceeded only from a fusible and vitreous quality; but as they do not, and as this porcelain is as fixed and as unfusible as the Japanese, its density, so far from being a fault, is a valuable quality. For we must allow, that of porcelains equal in other respects, those are best which are most firm and compact. Hence, the interior substance of the Japanese porcelain is esteemed for its greater density, compactness and lustre, than our vitreous or fritt porcelains, because these qualities indicate greater cohesion, and more intimate incorporation of its parts. For the same reason also the superior density of the Saxon porcelain ought to give it the preference to the Japanese. Besides, nothing would be easier than to give the Saxon porcelain the granulous texture of the Japanese, by mixing with the paste a certain quantity of sand. But the persons who perfected that manufacture were certainly sensible, that such a conformity to the Japanese porcelain would lessen the merit of theirs. For we know, that in general porcelains are better in proportion as they contain a larger proportion of clay or earth, and less of sand, flints, or other matters of that kind.

What we have said concerning porcelain in general, and the principal kinds of it, seems sufficient to give just notions of it, if not to persons who without considering the subject are determined to prefer the most ancient, to those, at least, who have made experiments on this subject, or who, having a sufficient knowledge of chemistry, are capable of studying and examining it thoroughly. We shall finish this article by giving a short description of the method of manufacturing porcelain.

The basis of the porcelains which we have called fusible, vitreous, or false porcelains, is called by artists a *fritt*; which is nothing else than a mixture of sand or of powdered flints, with salts capable of disposing them to fusion, and of giving them a great whiteness by means of a sufficient heat. This fritt is to be then mixed with as much, and no more, of a white tenacious earth, of an argillaceous or marly nature, than is sufficient to make it capable of being worked upon the wheel. The whole mixture is to be well ground together in a mill, and made into a paste, which is to be formed, either upon the wheel or in moulds, into pieces of such forms as are required.

Each of these pieces when dry is to be put into a case made of earthen ware (*s*); which cases are to be ranged in piles one upon another, in a furnace or kiln, which is to be filled with these to the roof. The furnaces are chambers or cavities of various forms and sizes, and are so disposed that their fire-place is placed on the outside opposite to one or more openings, which communicate within the furnace. The flame of the fuel is drawn within the furnace, the air of which rarefying, determines a current of air from without inwards, as in all furnaces. At first a very little fire is made, that the furnace may be heated gradually, and is to be encreased more and more, till the porcelain is baked,

(*s*) The cases are called by English potters, *seggars*. They are generally formed of coarser clays, but which must be also capable of sustaining the heat required without fusion. By means of these cases, the contained porcelain is preserved from the smoke of the burning fuel. The whiteness of the porcelain depends much on their compactness of texture by which the smoke is excluded, and on the purity of the clay of which they are made.

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that is, till it has acquired its proper hardness and transparency; which is known by taking out of the furnace from time to time, and examining, small pieces of porcelain, placed for that purpose in cases which have lateral openings. When these pieces shew that the porcelain is sufficiently baked, the fire is no longer to be supplied with fuel, the furnace is to be cooled, and the porcelain taken out, which in this state resembles white marble not having a shining surface, which is afterwards to be given by covering them with a vitreous composition, called the *glazing*.

The porcelain when baked and not glazed is called *biscuit*, which is more or less beautiful according to the nature of the porcelain. The manufacture of Sèvres excells all others in this respect, and it is therefore the only one which can produce very fine pieces of sculpture; that is, in which all the fineness of the workmanship is preserved, and which are preferable in smoothness and whiteness to the finest marble of Italy.

If this porcelain had no other merit, it would be sufficient to induce true connoisseurs to prefer it to any other matter, however solid, without this advantage.

As no piece of sculpture of this kind can preserve all the delicacy of its workmanship when covered with a glazing; and as sculptors avoid polishing their marble figures, because the lustre of the polish is disadvantageous; therefore in the manufacture of Sèvres, all figures, or little statues, and even some ornamental vases, are left in state of biscuit. The other pieces of porcelain are to be glazed in the following manner.

A glass is first to be composed suited to the nature of the porcelain to which it is to be applied, for every glass is not fit for this purpose. We frequently find that a glass which makes a fine glazing for one porcelain shall make a very bad glazing for another porcelain, shall crack in many places, shall have no lustre, or shall contain bubbles. The glazing then must be appropriated to each porcelain, that is, to the hardness and density of the ware, and to the ingredients of its composition, &c.

These glazings are prepared by previously fusing together all the substances of which they consist, so as to form vitreous masses. These masses are to be ground very finely in a mill. This vitreous powder is to be mixed with a sufficient quantity of water, or other proper liquor, so that the mixture shall have the consistence of cream of milk. The pieces of porcelain are to be covered with a thin stratum of this matter, and when very dry they are to be again put into the furnace, in the same manner as before, for the forming of the biscuit, and to be continued there till the glazing be well fused. The necessary degree of fire for fusing the glazing is much less than that for baking the paste.

The pieces of porcelain which are intended to remain white are now finished; but those which are to be painted and gilded must undergo further operations. The colors to be applied are the same as those used for enamel painting. They all consist of metallic calxes bruised and incorporated with a very fusible glass. Crocus of iron furnishes a red color: Cassius's precipitate of gold makes the purple and violet; copper calcined by acids and precipitated by an alkali gives a fine green; zaffre makes the blue; earths slightly ferruginous produce a yellow; and, lastly, brown and black colors are produced by calcined iron,

together

surface to that of glass has evidently suggested this notion; and it would be well founded, if the density and lustre of this porcelain proceeded only from a fusible and vitreous quality; but as they do not, and as this porcelain is as fixed and as unfusible as the Japanese, its density, so far from being a fault, is a valuable quality. For we must allow, that of porcelains equal in other respects, those are best which are most firm and compact. Hence, the interior substance of the Japanese porcelain is esteemed for its greater density, compactness and lustre, than our vitreous or fritt porcelains, because these qualities indicate greater cohesion, and more intimate incorporation of its parts. For the same reason also the superior density of the Saxon porcelain ought to give it the preference to the Japanese. Besides, nothing would be easier than to give the Saxon porcelain the granulous texture of the Japanese, by mixing with the paste a certain quantity of sand. But the persons who perfected that manufacture were certainly sensible, that such a conformity to the Japanese porcelain would lessen the merit of theirs. For we know, that in general porcelains are better in proportion as they contain a larger proportion of clay or earth, and less of sand, flints, or other matters of that kind.

What we have said concerning porcelain in general, and the principal kinds of it, seems sufficient to give just notions of it, if not to persons who without considering the subject are determined to prefer the most ancient, to those, at least, who have made experiments on this subject, or who, having a sufficient knowledge of chemistry, are capable of studying and examining it thoroughly. We shall finish this article by giving a short description of the method of manufacturing porcelain.

The basis of the porcelains which we have called fusible, vitreous, or false porcelains, is called by artists a *fritt*; which is nothing else than a mixture of sand or of powdered flints, with salts capable of disposing them to fusion, and of giving them a great whiteness by means of a sufficient heat. This fritt is to be then mixed with as much, and no more, of a white tenacious earth, of an argillaceous or marly nature, than is sufficient to make it capable of being worked upon the wheel. The whole mixture is to be well ground together in a mill, and made into a paste, which is to be formed, either upon the wheel or in moulds, into pieces of such forms as are required.

Each of these pieces when dry is to be put into a case made of earthen ware (s); which cases are to be ranged in piles one upon another, in a furnace or kiln, which is to be filled with these to the roof. The furnaces are chambers or cavities of various forms and sizes, and are so disposed that their fire-place is placed on the outside opposite to one or more openings, which communicate within the furnace. The flame of the fuel is drawn within the furnace, the air of which rarefying, determines a current of air from without inwards, as in all furnaces. At first a very little fire is made, that the furnace may be heated gradually, and is to be encreased more and more, till the porcelain is baked,

(s) The cases are called by English potters, *seggars*. They are generally formed of coarser clays, but which must be also capable of sustaining the heat required without fusion. By means of these cases, the contained porcelain is preserved from the smoke of the burning fuel. The whiteness of the porcelain depends much on their compactness of texture by which the smoke is excluded, and on the purity of the clay of which they are made.

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that is, till it has acquired its proper hardneſs and tranſparency; which is known by taking out of the furnace from time to time, and examining, ſmall pieces of porcelain, placed for that purpoſe in caſes which have lateral openings. When theſe pieces ſhew that the porcelain is ſufficiently baked, the fire is no longer to be ſupplied with fuel, the furnace is to be cooled, and the porcelain taken out, which in this ſtate reſembles white marble not having a ſhining ſurface, which is afterwards to be given by covering them with a vitreous compoſition, called the *glazing*.

The porcelain when baked and not glazed is called *biſcuit*, which is more or leſs beautiful according to the nature of the porcelain. The manufacture of Sévres excells all others in this reſpect, and it is therefore the only one which can produce very fine pieces of ſculpture; that is, in which all the fineneſs of the workmanſhip is preſerved, and which are preferable in ſmoothneſs and whiteneſs to the fineſt marble of Italy.

If this porcelain had no other merit, it would be ſufficient to induce true connoiſſeurs to prefer it to any other matter, however ſolid, without this advantage.

As no piece of ſculpture of this kind can preſerve all the delicacy of its workmanſhip when covered with a glazing; and as ſculptors avoid poliſhing their marble figures, becauſe the luſtre of the poliſh is diſadvantageous; therefore in the manufacture of Sévres, all figures, or little ſtatues, and even ſome ornamental vaſes, are left in ſtate of biſcuit. The other pieces of porcelain are to be glazed in the following manner.

A glaſs is firſt to be compoſed ſuited to the nature of the porcelain to which it is to be applied, for every glaſs is not fit for this purpoſe. We frequently find that a glaſs which makes a fine glazing for one porcelain ſhall make a very bad glazing for another porcelain, ſhall crack in many places, ſhall have no luſtre, or ſhall contain bubbles. The glazing then muſt be appropriated to each porcelain, that is, to the hardneſs and denſity of the ware, and to the ingredients of its compoſition, &c.

Theſe glazings are prepared by previouſly fuſing together all the ſubſtances of which they conſiſt, ſo as to form vitreous maſſes. Theſe maſſes are to be ground very finely in a mill. This vitreous powder is to be mixed with a ſufficient quantity of water, or other proper liquor, ſo that the mixture ſhall have the conſiſtence of cream of milk. The pieces of porcelain are to be covered with a thin ſtratum of this matter, and when very dry they are to be again put into the furnace, in the ſame manner as before, for the forming of the biſcuit, and to be continued there till the glazing be well fuſed. The neceſſary degree of fire for fuſing the glazing is much leſs than that for baking the paſte.

The pieces of porcelain which are intended to remain white are now finiſhed; but thoſe which are to be painted and gilded muſt undergo further operations. The colors to be applied are the ſame as thoſe uſed for enamel painting. They all conſiſt of metallic calxes bruiſed and incorporated with a very fuſible glaſs. Crocus of iron furniſhes a red color: Caſſius's precipitate of gold makes the purple and violet; copper calcined by acids and precipitated by an alkali gives a fine green; zaffre makes the blue; earths ſlightly ferruginous produce a yellow; and, laſtly, brown and black colors are produced by calcined iron, together

together with a deep blue of zaffre. Theſe colors being ground with gum-water, or with oil of ſpike, are to be employed for the painting of the porcelain with deſigns of flowers and other figures (*t*). For gilding, a powder or calx of gold is to be applied in the ſame manner as the colored enamels (*u*). The painted and gilded porcelains are to be then expoſed to a fire capable of fuſing the glaſs, with which the metallic colors are mixed. Thus the colors are made to adhere, and at the ſame time acquire a gloſs equal to that of the glazing. The gold alone has not then a ſhining appearance, which muſt be afterwards given to it by burniſhing with a blood-ſtone.

The operations for the unfuſible porcelains, and alſo for ſuch as are of the nature of ſtone-ware, are ſomewhat more ſimple. The ſands and ſtones which enter into their compoſition are to be ground in a mill: the earths or clays are to be waſhed: the materials are to be well mixed and formed into a paſte: the pieces are firſt rudely formed upon a potter's wheel; and when dry or half dry, they are turned again upon the wheel, and their form is made more perfect: they are then placed in the furnace, not to bake them, but only to apply a ſufficient heat to give them ſuch a ſolidity that they may be handled without breaking, and may receive the glazing. As the pieces of porcelain after this ſlight heat are very dry, they imbibe water readily. This diſpoſition aſſiſts the application of the glazing. The vitrifiable or vitrified matter of this glazing, which has been previouſly ground in a mill, is to be mixed with ſuch a quantity of water, that the liquor ſhall have the conſiſtence of milk. The pieces of porcelain are haſtily dipt in this liquor, the water of which they imbibe, and thus on their ſurface is left an uniform covering of the glazing materials. This covering, which ought to be very thin, will very ſoon become ſo dry, that it cannot ſtick to the fingers when the pieces are handled.

The pieces of this porcelain are then put into the furnace to be perfectly baked. The heat is to be raiſed to ſuch a height, that all within the furnace ſhall be white, and the caſes ſhall be undiſtinguiſhable from the flame. When, by taking out ſmall pieces, the porcelain is known to be ſufficiently baked, the fire is diſcontinued, and the furnace cooled. If the baking has been well performed, the pieces of porcelain will be found by this ſingle operation to be rendered compact, ſonorous, cloſe-grained, moderately gloſſy, and covered externally with a fine glazing. The painting and gilding of this porcelain are to be executed in a manner ſimilar to that already deſcribed. (*x*)

(*t*) *See the article* ENAMEL, *and the* Note *ſubjoined.*

(*u*) The ſeveral powders of gold employed for this purpoſe are deſcribed in a note ſubjoined to the article GILDING.

(*x*) I purpoſely avoid giving any opinion concerning the relative advantages and defects of the porcelains of Britiſh manufacture. I ſhall only add, that we have reaſon to believe, that the materials of genuine porcelain might be diſcovered in this iſland, if ſearch were made by intelligent perſons. The ſteatites or ſoap-rock of Cornwall is probably a good *kaolin*; and I have ſometimes found ſtones in England in which the white opake fluor above deſcribed was blended with a pure quartz, and which I am well convinced might be ſucceſsfully employed as a *petuntſe*. With pleaſure I hear that an ingenious gentleman has found a true kaolin and petuntſe in Devonſhire and Cornwall, and that he has lately eſtabliſhed a manufactory of genuine porcelain. It is to be hoped that he may ſucceed in the introduction of this very elegant and uſeful manufactory:

and

DXLVIII. PORCELAIN *of* Mr. REAUMUR. Mr. Reaumur having made many experiments to discover the nature of the materials which enter into the composition of the oriental porcelain, and having ascertained that all porcelain is an intermediate substance betwixt an earth and glass, very ingeniously thought of reducing glass ready made to the state of porcelain, by undoing the vitrification, or partly unvitrifying it: hence this kind of ware has been called *porcelain unvitrified.* Mr. Reaumur gave the quality of porcelain to glass; that is, he rendered glass of a milky color, semi-transparent, so hard as to strike fire with steel, unfusible, and of a fibrous grain, by means of cementation. The process which he published is not difficult. Common glass, such as that of which wine-bottles are made, succeeds best. The glass-vessel which is to be converted into porcelain is to be enclosed in a baked earthen case or segger. The vessel and case are to be filled with a cement composed of equal parts of sand and powdered gypsum or plaster; and the whole is to be put into a potter's kiln, and to remain there during the baking of common earthen ware; after which the glass vessel will be found transformed into such a matter as we have described.

This kind of porcelain has not a very white color, particularly on its surface; but for some purposes it may be useful, especially for chemical vessels. Mr. Reaumur has not explained how this transformation is effected. The cause of it probably is, that the vitriolic acid of the gypsum quits its basis of calcareous earth, and unites with the alkaline salt and saline earth of the glass, with which it forms a kind of salt or selenites different from the calcareous selenites, by the interposition of which matter the glass acquires the qualities of porcelain. (*y*)

and although many and great difficulties, besides the discovery of proper materials, must occur in the execution of that work, yet these are not insuperable.

(*y*) Mr. Reaumur says, that glass thus rendered opake, white, unfusible, and hard, is inferior in beauty to the oriental porcelain; but that in utility and every essential quality of porcelain it is equal to any, and even superior in the property of sustaining alterations of heat and cold.

The character given by Mr. Reaumur of this porcelain induced Dr. Lewis (who had also observed the changes produced upon glass-retorts exposed to violent heat in (a sand-bath) to make further experiments on this matter, an account of which he has published in the *Philosophical Commerce of Arts*, a work which we much wish to see prosecuted in the same able and useful manner in which it has been begun.

From Dr. Lewis's experiments we find the following results. 1. Green glass cemented with white sand received no change in a heat below ignition. In a low red-heat the change proceeded exceeding slowly; and in a *strong red-heat*, approaching to whiteness, the thickest pieces of glass bottles were thoroughly converted in the space of three hours. 2. The glass suffered the following *progression of changes* by continued heat: First, its surface became blue, its transparency was diminished, and a yellowish hue was observable when it was held between the eye and the light. Afterwards it was changed a little way on both sides into a white substance, externally still bluish; and as this change advanced still further and further within the glass, the color of the vitreous part in the middle approached nearer to yellow: the white coat was of a fine fibrous texture, and the fibres were disposed nearly parallel to one another, and transverse to the thickness of the piece: by degrees the glass became throughout white and fibrous, the external bluishness at the same time going off, and being succeeded by a dull whitish or dun color: by a still longer continuance in the fire the fibres were changed gradually from the external to the internal part, and converted

DXLIX. PORPHYRY. (z)

DL. POTASH. *See* ALKALI (FIXED).

DLI. POTTERY. The art of making pottery is intimately connected with chemistry, not only from the great use made of earthen vessels by

verted into grains; and the texture then was not unlike that of common porcelain. The grains, at first fine and somewhat glossy, appeared afterwards larger and duller, and at length the substance of the glass became porous and friable, like a mass of white sand slightly cohering. 3. Concerning the *qualities* of the converted glass Dr. Lewis observes, that the whiteness of the internal part was not inferior to that of porcelain, but that its surface was the least beautiful, that the thick pieces were quite opake, and that several thin pieces were semi-transparent: that while it remained in a fibrous state, its hardness became greater than that of glass, or of the common kinds of porcelain; it was capable of sustaining sudden changes of heat and cold better than any porcelain; and in a moderate white heat, it was fusible into a substance not fibrous, but vitreous and smooth, like white enamel: that when its texture had become coarsely granulated, it was now much softer and unfusible: and, lastly, that when some coarsely granulated, unfusible pieces which, with the continuance of a moderate heat, would have become porous and friable, were suddenly exposed to an intense fire, they were rendered remarkably more compact than before; the solidity of some of them being superior to that of any other ware. 4. No differences appeared in the internal color, hardness, texture, or the regular succession of changes, from the use of *different cementing substances*; though in external appearances the differences were considerable. All the pieces which had been surrounded with charcoal or with soot were externally of a deep black color, which did not disappear by exposure to a strong fire during an hour, with free access of air. Colored clays and sands communicated different shades of a brown color; and white earths gave whitish, greyish, or brownish tinges. White sand, calcined flints, and gypsum, gave in general the greatest whiteness, and tobacco-pipe clay the greatest glossiness and brightness. 5. Glasses composed of earths without alkaline salt, glass of lead, flint-glass, crown-glass, looking-glass plates, a glass prepared with calcined flints and a fixed alkaline salt, and even green glass which had been fused together with a ninth part of alkaline salt, suffered none of the above alterations by cementation. Green bottle-glass and common window-glass were most susceptible of these alterations. 6. The changes produced by cementation could not proceed from any absorption of matter from the cementing substance; because no increase of weight was given, and because the same changes were produced upon a piece of glass merely by heat, without any cementing substance. The real *cause of these changes* seems to be, that a part of the alkaline salt of the glass, to which the vitrified state of the earth is owing, exsudes by heat, and is imbibed by the surrounding matters, as appears from the concretion observable in these matters after a long cementation. Those glasses only are susceptible of change which contain but a small quantity of alkaline salt; because no more of this salt being contained than is necessary to give a vitrified state to the earth, any exsudation of it must in some measure unvitrify the glass, and approximate it more and more to the state of the earth of which it was formed. Perhaps also the first degree of change may partly depend on an alteration produced by the heat in the glass itself considered as a compound, or in the nature of its alkaline ingredients, which we know are liable, by exposure to fire, to lose something of their saline nature, and to be partly changed to earths.

(z) PORPHYRY is a compound stone consisting of Jasper, in which particles of feltspar, and sometimes of mica and basaltes, are interspersed. Its colors are green, red, black, brown, or dark-grey, varying according to the color of the jasper which is the basis of this compound stone, and of the quantity and colors of the interspersed particles. Porphyry is generally fusible by fire. Its fusibility is probably owing to the metallic matter with which the jasper is tinged, and to the basaltes or other fusible particles intermixed. The surface of this stone is generally covered with a whitish crust.

chemists,

chemists, but also because all the processes of this art, and the means of perfecting it, are dependent on chemistry. We must, however, acknowledge, that although chemists have most interest to procure good crucibles and other earthen vessels, this art has been left almost entirely to the potter. Mr. Pott is the first and the only chemist who has attended to this object. Besides many experiments related in his Lithogeognosia, from which much instruction may be received relating to the perfection of chemical vessels, he has written a treatise expresly on this subject, in which he gives many compositions for crucibles, the chief of which shall be mentioned in this article.

All kinds of pottery are in general made of clays or argillaceous earths; because these earths are capable of being kneaded, of easily receiving any form, and of acquiring much solidity and hardness by exposure to fire. But clays differ much in the effects produced upon them by fire. Some clays, which are of the purest kind, resist the most violent fire without receiving any other change than a considerable hardness; but still they are not rendered so hard and compact as other clays. A second kind of clays by exposure to violent heat acquires a hardness equal to that of flints, and a texture compact and glossy, like that of good porcelain; but they are nevertheless unfusible by the most violent heat. These qualities are occasioned by some fusible materials being mixed with them, as sand, chalk, gypsum, or ferruginous earth, which are in too small a quantity to effect a compleat, but only a beginning or partial fusion. Lastly, a third kind of clays is first hardened by fire, and afterwards is compleatly fused. This last kind of clay evidently contains the largest quantity of the fusible matters above-mentioned.

From the properties of these three principal clays we may conclude, that from clays alone three principal kinds of pottery may be produced. With the first kind of clay, pots or crucibles may be formed capable of sustaining the most violent fire without fusion, of containing melted metals, and even hard glasses not too fluid; but which, from want of sufficient compactness, are incapable of containing during a long time in fusion very fusible substances, such as nitre, glass of lead, glasses containing much arsenic, &c. by which substances their pores are pervaded. These clays are employed advantageously for the formation of large pots or crucibles used in glass-houses for containing hard glass, as bottle-glass.

With clays of the second kind may be made crucibles and other potteries, commonly called stone-ware. Potteries made with these earths, when sufficiently baked, are very sonorous, so hard as to strike fire with steel, capable of containing all liquids, of which the former kind, from their porosity, are incapable, and even resist the action of nitre, glass of lead, and other fluxes, when the earth of which they are formed is of good quality: but their hardness and density, which prevents their sudden expansion and contraction, by the hasty application of heat and cold, makes them liable to break in all operations where they are suddenly exposed to heat or to cold, as, for instance, in a furnace through which a strong current of air passes. If this kind of pottery had not this inconvenience, it would be the best and most perfect for the purposes of ordinary life and chemistry. Notwithstanding this inconvenience, this is the only pottery that is applicable in many occasions; and then all possible care must be taken

to prevent its breaking, by a very gradual application of heat and cold, and by protecting it from currents of cold air.

Lastly, with fusible clays may be made many kinds of vessels, which are cheap, as they require little fire to bake them; for all this kind of pottery is but slightly baked; hence its texture is coarse and porous. Some utensils are made of this pottery without glazing, as foot-stoves, &c. But in general they are covered with a glazing, without which water or other liquids would pass through their pores. Some of this pottery, which is finished with more care, is covered with a white enamel, which makes it very neat and like porcelain. This is called DELF WARE, *which see*. Other coarser potteries of this kind are glazed with glass of lead mixed with metallic calxes, or fusible colored earths, from which they receive various colors. This is the ordinary pottery.

Lastly, a fine kind of pottery is made of white clays, or of such as whiten in the fire, the surface of which is vitrified by throwing into the furnace, when the ware is sufficiently baked, some common salt and salt-petre. This pottery is called *English ware*, because the first and best was made in England. True, white English ware is not without merit; it is white, fine, well baked, and has some small degree of transparency when thin; so that it is intermediate betwixt porcelain and common stone-ware, and may therefore be called a semi-porcelain. (*a*)

Some of these potteries can sustain a sudden application of heat and of cold, sufficiently well for the uses of a kitchen, and are therefore called *fire-ware*: but these are always the coarsest, least baked, and the glazing of which is the softest. They also do not last long when much used; for it is a chimera to suppose, as some persons do, that pottery may be made capable of sustaining fire like a metal vessel. We are certain that the best of this kind which are employed for this purpose, break as soon as they are put upon the fire. They do not break so as to separate in pieces, or even to let liquors pass through them; but many small cracks are formed; which we may be assured of by the crackling heard upon their being first set on the fire, by the many cracks which may be perceived in their glazing, and by their ceasing to ring when struck, after they have been once heated. Each time that these vessels are set

(*a*) I have never seen any English stone-ware that had the semi-transparency and whiteness mentioned by the author. As the English stone-ware is composed of tobacco-pipe clay and ground flints, both which substances are perfectly unfusible, singly, or jointly, it cannot possess any degree of transparency. The use of the flints is to give strength to the ware, so that it shall preserve its form during the baking: whereas vessels made of clay alone, although unfusible by fire, and capable of acquiring, by having been exposed to an intense heat, the hardness of the best porcelain; while they are hot, are soft, sink by their weight, so as to lose the form given to them. This stone-ware is glazed in the manner mentioned by the author, but by means of common salt only, without any mixture of nitre. This glazing has not the beauty or smoothness of good vitreous glazings. Another kind of stone-ware, called *Queen's ware*, is made in England, and lately much used. It is composed of the same materials as the former, but with a less proportion of flints, as it is to be exposed to a less violent heat than the former ware; the vitreous glazing with which it is covered not being capable of sustaining such heat. Its color is less white than that of the former, having a yellowish tinge; but the ware is preferred on account of the smoothness of its glazing and neatness of its forms.

on

on the fire, many ſmall imperceptible cracks are formed in them, which by frequent uſe become ſo numerous, that the veſſel may be broken by the leaſt force. Thus all the difference betwixt the potteries which are intended to be uſed on the fire and the good ſtone-ware which is not intended for that purpoſe is, that this latter kind may be broken at once, when heated and cooled careleſsly, whereas the former is broken by degrees. Nevertheleſs, this fire-ware is uſeful, as it can ſerve for a ſhort time.

We ſhall not deſcribe the operation of making pottery, becauſe we have already ſpoken of it under the articles Delf-Ware *and* Porcelain, from which the common ware only differs, with regard to its manufacture, in its greater ſimplicity. We ſhall here add ſome obſervations concerning chemical veſſels, as retorts, muffles, and crucibles.

All the operations where great heat is employed require veſſels of baked earth; becauſe theſe alone can ſuſtain at once the action of violent fire and of chemical ſolvents. Veſſels made of good baked clay eminently poſſeſs theſe two qualities, and are the beſt which can be employed in chemiſtry; but as they have the inconvenience of breaking by ſudden application of heat and cold, and as many operations do not require veſſels ſo denſe, mixtures of earth have been uſed, of which crucibles are made, capable of being made ſuddenly red-hot, and ſuddenly cooled without breaking, and ſufficiently denſe to contain metals and other matters in fuſion during a long time. The beſt crucibles of this kind are brought from Heſſe, in Germany. Theſe crucibles are made with a good refractory clay, mixed, according to Mr. Pott, with two parts of ſand, of a middling fineneſs, from which the fineſt part has been ſifted. The mixture of ſand with clay produces two good effects; the firſt, to make the clay leaner, as it is called, and thus to prevent the clay from cracking by the contraction it ſuſtains during its drying; and, ſecondly, to prevent its acquiring too great cloſeneſs and compactneſs of texture by being baked. Thus we obtain crucibles moderately denſe, capable of containing metals and other things in fuſion, and infinitely leſs ſubject to break by heat and cold than thoſe made of pure clay.

The particles of the ſand mixed with clay in this compoſition for crucibles ought to be rather of a moderate ſize than very fine; becauſe, as Mr. Pott remarks, the former renders the crucibles much leſs apt to crack than the latter. In the ſecond place, that chemiſt forbids the uſe of ſand, flints, or other earths of that kind in the compoſition of crucibles intended to contain glaſſes or vitrifying matters a long time in fuſion; becauſe theſe vitreous matters act upon ſand, flints, and all thoſe called vitrifiable earths; by which means theſe crucibles are ſoon penetrated and melted.

This inconvenience is prevented, and all the advantages obtained from a mixture of ſand are procured by ſubſtituting to the ſand a good baked clay in groſs powder. In this manner are made the pots which contain the vitrifiable materials in glaſs-houſe furnaces, ſome of which reſiſt the continued fires employed there during three weeks or a month (*b*). The quantity of burnt clay

(*b*) The pots uſed in glaſs-houſes frequently ſuſtain a conſtant fire during ſeveral months, and ſometimes even a year. They become gradually more and more thin, the glaſs or flux contained probably diſſolving them thus ſlowly.

in the composition for crucibles varies in proportion to the nature of the crude clay, from 1, 2, 2½, or even three parts of the former, to one of the latter. In general, the stronger, more tenacious, and compact the crude clay is, the larger quantity of burnt clay ought to be mixed with it.

The crucibles made in France are composed on the same principles. They are made of clay mixed with broken butter-pots, which are a stone-ware made in Normandy and Piccardy. These crucibles resist admirably well sudden heat and cold, and they would be excellent if the crude clay which enters into their composition was capable of resisting a violent fire: but this clay being mixed with martial and pyritous matters swells in the fire, and begins to melt. Besides, these crucibles owe their good quality of not breaking by sudden application of heat and cold to their little density, which is attended with this inconvenience, that they are penetrable by very fluid matters.

We may, from what has been said, perceive the difficulty, perhaps the impossibility, of making perfect crucibles. Mr. Pott has made so many experiments on this subject, that he seems to have exhausted it. The basis of all his compositions was clay; but this he mixed in different proportions with metallic calxes, calcined bones, calcareous stones, talks, amianthus, asbestus, pounce-stones, tripoli, and many others, from none of which did he obtain a perfect composition, as may be seen from his Dissertation: hence we conclude, that we must have in our laboratories crucibles of different kinds suitable to the several operations; Paris crucibles, when the matters contained are not too fluid, and the fire is not too strong; Hessian crucibles, when similar matters are to be exposed to a violent heat; and crucibles of baked clay for vitrescent matters and penetrating fluxes.

Crucibles may possibly be made better than any hitherto known, and of more extensive use. The essential point is to obtain a very refractory clay free from pyritous matter and ferruginous earth, from which the sand must be washed. This must be mixed with two or three parts of the same clay baked and pounded grosly; and of this mixture or paste crucibles must be formed in moulds, and baked in a very strong fire. As retorts and cucurbits are designed for the distillation of liquors generally very corrosive and penetrating, they ought to be made of stone-ware. (c)

(c) To what the Author of the Dictionary has said concerning *crucibles*, I shall add some farther extracts from Mr. Pott's *Dissertation* above-quoted.

1. Crucibles made of fat clays are more apt to crack, when suddenly exposed to heat, than those made of lean or meagre clays. *Meagre clays* are those in which a considerable quantity of sand is mixed with the pure argillaceous earth, and *fat clays* are those which contain but a small proportion of sand. 2. Some crucibles become porous by long exposure to fire, and imbibe part of the contained metals. This inconvenience is prevented by glazing the internal and external surfaces, which may be done by moistening these with oil of tartar, or by strewing upon them when wetted with water, powdered glass of borax. These glazings are not capable of containing glass of lead. 3. Crucibles made of burnt clay *grosly powdered*, together with unburnt clay, were much less liable to crack by heat than crucibles made of the same materials, but in which the burnt clay was *finely powdered*, or, than crucibles made entirely of unburnt clay. 4. If the quantity of unburnt clay be too great, the crucible will be apt to crack in the fire. Crucibles made of ten ounces of unburnt clay, ten ounces of grosly powdered burnt clay, and three drams of calcined vitriol, are capable of retaining melted metals, but

DLII. POWDER. This name is given in general to all dry ſubſtances when divided into very ſmall parts. As in many chemical operations the ſubſtances employed muſt be neceſſarily reduced into very fine powder, different methods have been invented for this purpoſe according to the nature of the ſubſtances to be powdered. *See* DIVISION..

In pharmacy many remedies are in form of powder, and which are called *powders*; but theſe do not belong to our ſubject. Some chemical preparations and mixtures are known by the name of powder, as the *powder of Algaroth*, *gun-powder*, *fulminating powder*, of all which we ſhall treat.

DLIII. POWDER *of* ALGAROTH. This preparation, called alſo *emetic powder* or *mercurius vitæ*, is a kind of calx of regulus of antimony, ſeparated from the butter of antimony by water alone.

The marine acid, which cannot be united to the regulus of antimony but by particular proceſſes and when it is highly concentrated, as we ſee from the operation of butter of antimony, is much diſpoſed to ſeparate from it; and accordingly is ſeparated, at leaſt the greateſt part of it is ſeparated, by dilution with a ſufficient quantity of water. When therefore water is poured upon butter of antimony, the ſame thing happens as when water is mixed with the ſaline combination of the vitriolic acid with mercury; that is, the greateſt part

but are pervaded by glaſs of lead. The following compoſition is as good or better than the preceding. Seven ounces of unburnt clay, fourteen ounces of groſsly powdered burnt clay, and one dram of calx of vitriol. Theſe crucibles may be rendered more capable of containing glaſs of lead, by lining their internal ſurfaces, before they are baked, with unburnt clay diluted with water. They may be further ſtrengthened by making them thicker than is uſually done, or by covering their external ſurfaces with ſome unburnt clay, which is called *arming* them. 4. The compoſition of which crucibles the moſt capable of containing glaſs of lead were made, was eighteen parts of groſsly powdered burnt clay, as much unburnt clay, and one part of fuſible ſpar. Theſe crucibles muſt not, however, be expoſed too ſuddenly to a violent heat. 5. Crucibles capable of containing very well glaſs of lead were made of twenty-four parts of unburnt clay, four parts of burnt clay, and one part of chalk. Theſe required to be armed. 6. Plume-alum powdered, and mixed with whites of eggs and water, being applied to the internal ſurface of a Heſſian crucible, rendered it capable of containing glaſs of lead during a long time. 7. One part of clay and two parts of Spaniſh chalk made good crucibles. The ſubſtance called Spaniſh chalk is not a calcareous earth, but appears to be a ſteatites. 8. Two parts of Spaniſh chalk and one part of powdered tobacco-pipes made a good compoſition for lining common crucibles. 9. Eight parts of Spaniſh chalk, as much burnt clay, and one part of litharge, made ſolid crucibles. 10. Crucibles made of black-lead are fitter than Heſſian crucibles for the melting of metals; but they are ſo porous, that fuſed ſalts paſs entirely through them. They are more tenacious than Heſſian crucibles, are not ſo apt to burſt in pieces, and are more durable. 11. Crucibles placed with their bottoms upwards are leſs apt to be cracked during the baking than when placed differently. 12. The paſte of which crucibles are made ought not to be too moiſt, elſe when dried and baked they will not be ſufficiently compact: hence they ought not to be ſo moiſt as to be capable of being worked on a potter's lathe, but they muſt be formed in braſs or wooden moulds. *See Mr. Pott's Diſſertation on Chemical Veſſels.*

Mr. Scheffer ſays, that the beſt crucibles cannot eaſily contain metals diſſolved by ſulphur, in the operation of parting by means of ſulphur. *See* PARTING. He ſays, that they may be made much more durable and ſolid, by ſteeping them a few days in linſeed oil, and ſtrewing powdered borax upon them before they are dried. *Mem. Sued.* xiv. 1752.

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of the regulus of antimony is separated from the marine acid, or at least it retains too little of this acid to continue soluble, but is separated in form of a white precipitate, while the rest of the regulus remains dissolved in water by means of the superabundant acid.

The acid liquor in which the precipitate or powder of algaroth is formed has been called by the ancient chemists, very improperly, the philosophical spirit of vitriol; for it does not contain an atom of vitriolic acid. We must not believe that it is pure marine acid, for it retains, as we have said, a small portion of the regulus of antimony; the proof of which is that this earth may be precipitated and rendered sensible by an alkali.

The earth thus precipitated by water from butter of antimony, after it has been frequently and perfectly washed with much distilled water, is called *powder of Algaroth*, from the name of a physician who used it as a remedy. This preparation of antimony given in doses from a grain to three or four grains is a powerful emetic and purgative; but unconstant in its effects, and even dangerous, as all the preparations of antimony are which are not in a saline state.

Most chemists believe that the powder of algaroth retains a part of the acid of butter of antimony, and attribute its effects partly to this acid. When this powder has not been perfectly washed, it does indeed retain some acid, which may give it a degree of causticity. But we are not certain that all the acid cannot be washed from it by much water, or by being boiled in a large quantity of water. Mr. Beaumé pretends that it is very possible; but however well washed this powder may have been, it still preserves an emetic quality, nearly as great as that of glass of antimony; which is not surprising. For if we suppose that this antimonial earth was absolutely deprived of acid, yet as it was combined with the marine acid, which does not deprive metals of all their phlogiston, it retains enough of this principle to possess an emetic quality, as in general all antimonial calxes do when not perfectly dephlogisticated.

Lemery says, that the powder of algaroth cannot be dissolved either by spirit of nitre or by ordinary aqua regia, but that it is soluble by a mixture of the spirit of nitre, of sea-salt, and of vitriol. As that chemist is very accurate, what he says is probably true. I shall nevertheless observe, that I have dissolved this powder perfectly and entirely with cream of tartar, in the usual manner of dissolving glass of antimony in the preparation of emetic tartar, and thus obtained a neutral crystallizable salt. This experiment induces me to believe, that powder of algaroth may be used advantageously for the preparation of an emetic tartar, of more certain and more uniform quality than that which is prepared from glass of antimony. *See the reasons for this opinion, at the word* TARTAR (EMETIC). *See also the articles* ANTIMONY, BUTTER *of* ANTIMONY, *and* BEZOAR MINERAL.

DLIV. POWDER (GUN). Gun-powder is an intimate mixture of 75 parts of purified nitre, of $15\frac{1}{2}$ parts of charcoal, and of $9\frac{1}{2}$ parts of sulphur. The quickness of the kindling of this composition, and the violence of the explosion occasioned by this sudden inflammation, is universally known. The theory of the detonation of gun-powder is exactly the same as that of the detonation of nitre with any other inflammable matter. Therefore we refer to the article DETONATION *of* NITRE for this theory.

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The goodneſs and force of gun-powder depend upon two eſſential points, firſt, that all the contained nitre be inflamed; and ſecondly, that this inflammation be made in the ſhorteſt time poſſible, and almoſt in an inſtant.

The proper quantities of ſulphur and of charcoal in the compoſition of nitre procure the inflammation of all the contained nitre; and the quickneſs and force of this inflammation depends upon the intimacy and accuracy of the mixture of the component parts of the powder.

From experience we find that the proportions of the ſeveral ingredients mentioned above are the beſt, that is, that they are ſufficient for the detonation of the whole nitre. A larger quantity of ſulphur and charcoal would leſſen the force of the powder; becauſe altho' theſe ſubſtances be inflammable, yet the force of their inflammation is nothing in compariſon of detonating nitre. Care muſt be taken that no uninflammable matters be mixed with the gun-powder, and therefore the nitre muſt be very well purified, and freed from the common ſalt mixed with it, which is not inflammable; and alſo from the ſalts with earthy baſes, which are contained in the mother water of nitre, and which have the bad quality of attracting powerfully the moiſture of the air, as this quality renders theſe ſalts capable of ſpoiling powder, in other reſpects good.

The quickneſs of the inflammation of gun-powder depends not only on the purity of the nitre and on the juſt proportion of the ingredients, but alſo on the accurate diſtribution, and the intimate mixture of theſe. The reaſon of this is very evident. As the ſalt-petre cannot be inflamed but by means of immediate contact with ſome inflammable matter, we may eaſily perceive that the finer the particles are of the ſalt-petre, and alſo of the ſulphur and charcoal, and the more intimately theſe three ingredients are mixed, the greater is the number of the points of contact, ſince the ſurface of each of the ingredients is thereby encreaſed; and hence the quicker the detonation muſt be. Accordingly all the operations in the making of gun-powder are to compleat theſe two intentions.

For this purpoſe, nitre of the third boiling, and well purified, is choſen, and alſo very pure ſulphur and good charcoal. The charcoal of light woods is generally employed; but Mr. Beaumé, who has very minutely and accurately examined this matter, affirms from experience, that the charcoals of heavy and hard woods, if they have been well made, are as fit for the purpoſe. Theſe three ingredients are mixed in the proportions above-mentioned, and a very fine diviſion and intimate mixture are made of them, by pounding them together, during twelve hours, in a wooden mortar, and with a wooden peſtle. This mixture muſt be carefully moiſtened from time to time with ſome water, to prevent the matters when too dry from being raiſed and diſſipated by this long trituration, and to prevent the mixture from kindling by the heat occaſioned by the repeated ſtrokes of the peſtle. In large works, a mill is employed for this trituration, in which wooden mortars are diſpoſed in rows, and in each of which a peſtle is moved by the arbor of a wheel turned by water, as in paper mills.

When the trituration is finiſhed, the powder is made. Nothing then remains to be done but to dry it very ſlowly, but compleatly. The powder is in this ſtate compoſed of very fine parts, which are therefore liable to moiſten in the

air, to adhere to any thing, to soil the fingers and the inside of fire-arms, into which also it does not easily slide. These inconveniencies are remedied by reducing it to small smooth grains, larger for cannons, and smaller for muskets.

The operations by which the powder is reduced into grains are very simple, and well imagined. For this purpose, it is placed to a certain thickness upon sieves, the holes of which are of a proper size; upon this stratum of powder a thick piece of wood is placed horizontally, and presses upon the surface of the powder. All this apparatus is to be agitated horizontally in several directions. The weight of the piece of wood forces the powder to pass through the holes of the sieve, and to form itself into molecules of the size of the holes. The powder is by this method granulated, but it is not rendered smooth. In its rough state it is used for artillery; but for small arms it must be smoothed, and this is effected by an operation as simple as the preceding.

For this purpose a hollow cylinder or cask is mounted upon an axis, which is to be turned by a wheel. This cask is to be filled half full of the powder to be smoothed, and it is to be turned six hours. The friction occasioned by this motion of the parts of the powder against each other is sufficient to smooth their surfaces. The granulation and smoothing of the gun-powder cannot be performed without a part of it being reduced to a fine powder, which is to be separated from the rest by a searce, and to be afterwards granulated. Those who require more particular information concerning this manufacture, or other arts and trades, may consult the *Dictionnaire portatif des arts & des metiers*. *See the articles* ACID (NITROUS); NITRE; DETONATION *of* NITRE; SULPHUR; COAL. (*d*)

DLV. POWDER *of the* CHARTREUX. *See* KERMES.

DLVI. POWDER (FULMINATING). This powder is a mixture of three parts of nitre, two parts of the dry alkali of tartar, and one part of sulphur. It is called fulminating, because when it is put upon a gentle fire, in an iron spoon, and slowly heated, it detonates with astonishing violence and noise as soon as it receives the proper heat.

The most remarkable circumstances in this experiment are, that this powder does not require to be forcibly confined, as gun-powder does, to make a great

(*d*) Mr. Beaumé analysed a pound of the gun-powder made for the French ordnance. By boiling it in water he extracted 12 ounces of salt petre; and by exposing the residuum to a heat just sufficient for the slow combustion of the sulphur, he found that it contained two ounces of sulphur and two ounces of charcoal.

Some persons, missed by an experiment of Dr. Hales, which shews that burning sulphur does not generate elastic air, but destroys the elasticity of common air, have imagined that the sulphur was an unnecessary and even hurtful ingredient of gun-powder. Mr. Beaumé, having made experiments on that subject, found that by addition of the sulphur, the force of gun-powder was nearly doubled.

The use of sulphur, as an ingredient in gun-powder, seems to be not to encrease the explosion immediately by its own combustion, but to accelerate the combustion of the other ingredients, which it does by its property of being much more easily inflammable than the charcoal. The charcoal not only concurs with the sulphur in supplying the inflammable matter which causes the detonation of the nitre, but also considerably adds to the explosive power of the detonating nitre, by the quantity of elastic vapor expelled during its combustion. Concerning the whole explosive force of gun-powder, *see a Note subjoined to the article* DETONATION *of* NITRE.

explosion,

explosion, and also that heat must be applied slowly; for the fulmination is less strong when the powder is hastily heated; and although a single gros (e) of this powder is sufficient, when heat is slowly applied, to make a noise as considerable as that of a cannon, and to produce an explosion dangerous to by-standers; yet a much larger quantity may be thrown upon lighted coals without danger, and even without explosion, because the nitre does then only gently detonate, as it does when it is alkalised by charcoal.

The explanation of these singular effects is deducible from the theory of the detonation of nitre. The explosion produced by nitre, when inflamed with any combustible matter, is so much stronger as the quantity inflamed at once is larger, so that it is the strongest possible when all its parts kindle at once, and instantaneously: but this happens in the experiment of fulminating powder. When it is very slowly heated, it is first liquefied: a kind of liver of sulphur is formed by the combination of the alkali with the sulphur which enters into the composition of this powder; the phlogiston of the sulphur is almost entirely disengaged, and reduced into a vapor which penetrates the mass on all sides, and is equally distributed betwixt the parts of the nitre, which is then also fused. Lastly, when the heat is strong enough to kindle any part of the powder when brought to this state, all the others kindle also; both because, by having been slowly heated, they have nearly the same degree of heat, and also because they are all disposed in the most advantageous manner to inflammation. They therefore all kindle at the same time; and this instantaneous explosion strikes the surrounding air with such violence and rapidity, that this fluid has not time to give way to the sudden percussion, and consequently resists as much the fulmination of this powder, as the chamber of a gun resists the fulmination of gun-powder. Hence fulminating powder does not require to be closely confined, as gun-powder does, to make a much more considerable noise.

This circumstance also is peculiar to fulminating powder, that some instants before its explosion, a light blue flame appears upon its surface; which is nothing else than the phlogistic vapors beginning to kindle. No more fire or flame is perceptible during its fulmination: this proceeds from the quickness of the explosion, and the violence of the commotion of the air, by which the flame is extinguished and suffocated as soon as it is formed, and before it can be perceived. Hence also fulminating powder does not generally kindle the combustible bodies in contact with it, because the time of its inflammation is too short.

This powder differs in these two last phenomena from gun-powder, but they are common to it with fulminating gold. If we were certain that *nitrous sulphur* can subsist ready formed uninflamed, these effects would induce us to believe that it subsists already combined in fulminating powder and in fulminating gold, some time before their explosion, as Mr. Beaumé thinks. We cannot be certain of this, unless we could obtain nitrous sulphur single and uninflamed, as we can vitriolic sulphur and phosphorus. *See* ACID (NITROUS), NITRE, DETONATION *of* NITRE, LIVER *of* SULPHUR, GOLD (FULMINATING), POWDER (GUN), *and* SULPHUR.

(e) A gros is 72 grains.

DLVII. PRECIPITATION, *and* PRECIPITATES.

Precipitation is one of the most general and important operations of chemistry. The term *precipitation*, in its most extensive sense, is applicable to all chemical decompositions made by an intermediate substance, that is, to all operations in which two bodies are disunited, by employing a third body which has the property of uniting with one of these, and thereby of separating the other. Hence we see that every precipitation is effected by means of the affinity of a precipitant, much stronger than that of the precipitate with the substance from which it is separated. This is the third case of affinity; when three substances act upon each other. *See* AFFINITY.

This surprizing property that certain substances possess of separating others strictly united, is the true efficient cause of many chemical decompositions which could never have been performed by other means. Thus, for instance, we should never have known the acid of sea salt, sedative salt, and many other very important substances in chemistry, without the assistance of some acids more powerful than these, and capable of separating them from the bases to which they are united.

Although all these decompositions essentially belong to precipitation, yet use has confined this term to those operations only in which the substance becomes palpable when it is separated, and consequently falls by its gravity to the lower part of the vessel in which the operation is made. From this fall of the separated substance the operation has been called *precipitation*; and the substance separated, and collected at the bottom of the vessel, has been called *precipitate*.

We shall not say any thing here concerning the cause of precipitation, because our knowledge is not yet sufficiently extensive to enable us to affirm any thing upon the subject. An hypothesis relating to it may be found under the article GRAVITY. In this article we shall only mention the principal phenomena of precipitations, and the most essential properties of several precipitates.

Precipitation is never occasioned but in fluid matters; and as bodies may be rendered fluid either by fire or by water, two kinds of precipitations may be distinguished, one by the humid way, and the other by the dry way. In the first class ought to be ranged all decompositions of salts with earthy or metallic bases, which salts must be dissolved in water when their bases are to be separated from their acids by proper intermediate substances. The second class includes the separations of metals and of other solid and fusible matters from each other, which are effected by fusion and mixture with the separating substances. These two kinds of precipitation do not essentially differ: but many real differences distinguish the separated substances, or all those to which the general name of precipitate is given. This name has been given very improperly to several preparations which are not precipitates. Such are the *red precipitate*, *precipitate per se*, and some others. And amongst the preparations which may properly be called by this name, because they are substances separated from other substances by intermediate bodies, many do essentially differ from others, and ought therefore to be distinguished by different names.

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When a body is decompoſed by means of an intermediate ſubſtance, and a precipitate is formed by this decompoſition, this precipitation can be effected only by the intermediate ſubſtance uniting with one of the component matters of that body; and conſequently a new compound is always formed in theſe operations. Sometimes the ſeparated matter, being no longer ſoluble, becomes ſenſible, and falls as a precipitate, while the new compound remains diſſolved. In other inſtances, the ſeparated ſubſtance remains diſſolved, while the new combination, not being ſoluble, is precipitated. This depends on the nature of the ſubſtances which act one upon another in theſe operations; but we may eaſily perceive that the precipitates of the former kind are ſimple, and thoſe of the latter are compound.

Some modern chemiſts conſider theſe ſimple precipitates only as true precipitates, or which ought to be ſo called. Nevertheleſs, we muſt acknowledge that precipitates of the ſecond kind have all the requiſites to entitle them to the name of precipitate; and no inconvenience attends the giving to them that name, provided they are diſtinguiſhed from the former kind by the denomination of *compound precipitates*.

Earths and metals, when ſeparated from acids by means of alkalis or other metals, are ſimple precipitates, and when ſeparated from acids by other acids, are compound precipitates. For inſtance, calcareous earth united with nitrous and marine acids may be ſeparated from theſe by the vitriolic acid: and if this ſeparation is effected by pouring vitriolic acid into a ſolution of nitre or of marine ſalt with calcareous baſis, the liquors which were before clear will by this addition of vitriolic acid be rendered turbid and milky, and a ſediment or white precipitate will ſoon be formed at the bottom of the liquor. This precipitate is nothing elſe than the calcareous earth which was united with the nitrous or marine acids, and which being ſeparated from theſe acids by the vitriolic acid, unites with this latter and forms a new compound, a ſelenites, the greateſt part of which, not being capable of remaining diſſolved in the liquor, is precipitated. *See* SELENITES.

In the ſame manner, when vitriolic acid or any ſalt containing it is mixed with a ſolution of ſilver, of lead, or of mercury by the nitrous acid, a precipitate is ſoon formed, which is a combination of the metal with the vitriolic acid. *See* VITRIOLS.

The ſame thing may be ſaid of the corneous metals, which are combinations of theſe metals with marine acid, by which they have been ſeparated from nitrous acid. *See* LUNA CORNEA, *and* PLUMBUM CORNEUM.

All the precipitates above-mentioned are really new combinations of the precipitated ſubſtance with the precipitating acid; and which only ſeparate from the liquor, and appear as precipitates, becauſe they are are not very ſoluble, and the liquor contains too little water to keep them ſuſpended. This may be proved by adding a ſufficient quantity of water, by which this kind of precipitates will be entirely diſſolved. Nevertheleſs this circumſtance does not prevent their being precipitates, when they are actually made by precipitation. For amongſt the precipitates conſidered as ſimple, and to which many chemiſts would confine the name of precipitate, perhaps there is not one really ſimple. Modern chemiſts have obſerved, that all precipitates in general draw along with them a greater or leſs quantity of ſome other ſubſtances during

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the precipitation. They either retain a part of the substance with which they were united before precipitation, or a part of the precipitant, and frequently even a certain quantity of each of these matters. This depends on the nature of the bodies which act upon one another, on their proportions, and on concomitant circumstances. If any precipitates can be considered as pure and simple, certainly a metal precipitated from an acid by another metal may, as, for instance, silver and mercury separated from the nitrous acid by copper, or copper separated from acids by iron; because the precipitated metal resumes its natural color, lustre, and metallic properties. Nevertheless, when we subject these metallic precipitates to accurate trials, we discover that they are allayed with a small quantity of the precipitating metal. In general, precipitates and the different circumstances of precipitation have been hitherto but superficially examined. It is a subject, no less important than new, which deserves attention, and is replete with many discoveries.

After these explanations which we thought necessary concerning precipitation and precipitates in general, we proceed to treat of the principal chemical preparations called precipitates; because these which are not called precipitates, although they really be so, are treated of under other articles.

MERCURIAL PRECIPITATES.

DLVIII. PRECIPITATE (WHITE). This is mercury separated from nitrous acid by marine acid, with which it then unites. White precipitate is made by pouring a solution of common salt in distilled water into a solution of mercury in nitrous acid, till no more precipitate falls. When the sediment is collected at bottom, the supernatant liquor is to be decanted, and the precipitate is to be washed several times with distilled water, and then dried.

This precipitate of mercury is one of those called compound. It is a combination of mercury with the acid of common salt; for in this operation, as well as in the precipitation of the corneous metals, the metallic matter is only separated from the nitrous acid by means of the combination it forms with the marine acid. In this precipitation, then, the phenomena are similar to those which happen in the formation of luna cornea and plumbum corneum. 1. White precipitate may be made by pure marine acid. 2. When it is made by common salt, or other salt containing marine acid, two decompositions happen, and two new combinations are formed. The nitrous acid which was originally united with the mercury combines with the substance that was united with the marine acid, and forms a new nitrous salt, which remains dissolved in the liquor. When common salt is employed, cubic nitre is formed. If marine salt with an earthy basis is used, the liquor after the precipitation, contains a nitre with earthy basis. Upon this subject *see the article* AFFINITY. 3. All the mercury, although entirely separated from nitrous acid and united with marine acid, is not precipitated in the present occasion, because it is reduced to a saline compound essentially soluble in water; and consequently the liquor contains as much of it as it can dissolve, and another part of it is dissolved by the water employed to wash it. Similar events happen also in the precipitation of silver and of lead by marine acid. Accordingly, if an alkali be added to clear the liquor decanted from these precipitates, or even to the water employed to wash them, another precipitate will be formed; but this latter

latter is of a different nature, and is simple in comparison of the former, since it does not contain any acid combined directly with the metallic substances, or, at least, much less of the acid.

Lemeri gives another process for making a white precipitate, which consists in dissolving four ounces of sal ammoniac in a pound of water; to which is to be added an equal quantity of corrosive sublimate; all which could not be entirely dissolved alone in that quantity of water, but may by means of the sal ammoniac. *See* SUBLIMATE (CORROSIVE), *and* TINCTURE *of* MERCURY. Into this solution liquid fixed alkali is to be added, till no more is precipitated. The precipitate is very white, and it has been accordingly called white precipitate by several chemists; but it ought not to be confounded with the white precipitate formed by adding marine acid or common salt to a solution of mercury in nitrous acid; for they are evidently very different.

We may remark, that the color of this precipitate of Lemeri is influenced by the sal ammoniac; for although this precipitate be very white, the precipitate formed by adding fixed alkali to a solution of corrosive sublimate in water is brick-colored. The whiteness of the former precipitate then proceeds from the great quantity of marine acid, and even of the volatile alkali of the sal ammoniac, which affect this precipitation. This proves, that precipitates reputed simple are not so; and that they draw along with them part of the substances to which they were united, and of the precipitating substances. Great differences may be observed in this respect amongst precipitates in general, according to the quantity and proportions of substances which concur to the precipitation.

DLIX. PRECIPITATE (YELLOW). As chemists have given many different forms to mercury, to adapt it to medicinal uses and to chemical processes; so they have made various precipitates of it, and have given the name of precipitate to other mercurial preparations which in fact are not precipitates. These are chiefly denominated from their colors, without adding any epithet to shew that they are mercurial. Thus *white precipitate*, *yellow precipitate*, *red precipitate*, &c. are preparations of mercury. Yellow precipitate is mercury dissolved by vitriolic acid, from which it is afterwards separated by addition of water alone; it is then in form of a yellow powder: but as this precipitate is better known by the name of TURBITH MINERAL, we shall treat of it under that article.

DLX. PRECIPITATES (BLACK *and* ROSE-COLORED). Lemeri, who mentions many precipitates of mercury of different colors, says, that if a solution of mercury in spirit of nitre be precipitated by urine, instead of a solution of common salt, a rose-colored precipitate of mercury will be formed; and that if afterwards some fixed or volatile alkali be added to the liquor from which the rose-colored precipitate has been formed, another precipitate which is black will be obtained.

Much common salt being contained in urine occasions the rose colored precipitate, which is essentially the same as the white precipitate obtained by pure sea-salt or marine acid. The redness of its color probably proceeds from some reddish earthy or saline-earthy matter contained in urine, which it draws along with it.

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The blackneſs of the precipitate obtained afterwards by adding alkali proceeds from the oily and phlogiſtic parts of the urine, which are added ſuperabundantly to the mercury, and which always blacken white metals, as ſilver, lead, biſmuth, theſe metals being ſuſceptible of receiving inflammable matter ſuperabundantly, when they are expoſed to vapors of ſulphur, of liver of ſulphur, or when they are precipitated by this latter ſubſtance. *See* LIVER *of* SULPHUR.

DLXI. PRECIPITATE PER SE. This preparation of mercury is very improperly called a precipitate; becauſe it is not ſeparated from one ſubſtance by means of another ſubſtance, as all true precipitates are, but is only mercury reduced to a red powder by a kind of calcination.

To make this preparation, three or four ounces of mercury are put into a flat-bottomed glaſs matraſs, the neck of which is very long, and the opening of a capillary ſize. This matraſs, the belly of which ought not to be entirely full of mercury, is to be placed in a ſand-bath, and heated till the bottom of the veſſel containing the ſand be red-hot. This heat is to be continued during two or three months. The mercury gradually loſes its luſtre, and part of it is converted into a red powder, which does not mix with the remaining fluid mercury, but floats upon the ſurface of the mercury, or adheres to the ſides of the veſſel. The operation may be ſhortened by uſing a greater number of matraſſes, all which may be placed in the ſame bath. When enough of this red powder is obtained, it is to be collected and ſeparated from the remaining fluid mercury. This is called *precipitate per ſe*, or *by itſelf*, or *red precipitated mercury without addition*.

This preparation of mercury we have received from the alchemiſts, who ſpared no pains nor labor to change mercury and to fix it. They received great hopes from the change of color, the want of fluidity, and the diminution of volatility which the mercury ſuffers by this operation. Although the mercury is much diſguiſed by theſe changes, yet it is not eſſentially altered, becauſe it may be reduced to fluid mercury by heat without addition. We cannot preciſely explain the phenomena of this operation. Different opinions are formed concerning them. Mr. Baron conjectures, that they are cauſed by the union which mercury contracts by means of its being much divided with the ſaline particles contained in air. We ſee indeed from turbith mineral and red precipitate, that mercury is diſpoſed to take the form and qualities of the precipitate per ſe, by an union with a ſmall quantity of ſaline ſubſtance. Mr. Beaumé thinks, on the contrary, that the mercury is truly calcined, that it loſes part of its phlogiſton; and that, when it is expoſed to heat, it is again reduced to its metallic ſtate by the addition of the inflammable principle which paſſes through the containing veſſels, and again combines with it. This opinion is not improbable; but more experiments and reſearches are wanting to decide concerning it. I ſhould be, nevertheleſs, ſufficiently diſpoſed to believe, that a part of the inflammable principle contained in fluid mercury is ſuperabundant to it, ſlightly adherent, and may be eaſily loſt and recovered.

DLXII. PRECIPITATE (RED). If a ſolution of mercury in nitrous acid be reduced to dryneſs by evaporation, and the mercurial nitre thence formed be put into an open matraſs ſet in a ſand-bath, with a fire gradually

gradually encreasing, the nitrous acid will disengage itself from the mercury, and evaporate in a red vapor. While the acid evaporates, the saline mercurial mass loses its original whiteness, becomes yellow, then orange, and lastly red.

This red matter, when separated from the matrass, (which must be broken for that purpose) and pulverised in a glass mortar, is the *red precipitate*, as it is improperly called; it not being a precipitate, but a mercurial nitre from which the greatest part of the acid is expelled by the fire, without the application of any intermediate substance. The red color of this preparation is caused by the great division of the molecules; for, from the example of the precipitate per se, and of several true mercurial precipitates, which also are red, we learn that this is the color assumed by mercury when it is not fluid, when its parts are much divided, and when it has not a superabundant quantity of phlogiston.

Notwithstanding the calcination which mercurial nitre sustains in this operation, all its nitrous acid is not expelled. The mercury still retains a quantity of acid equal to the ninth part of its weight, as Mr. Lemeri observes. This preparation is therefore corrosive, and only used externally. Several authors propose to render it milder by burning spirit of wine two or three times over it. It is then called *arcanum corallinum*, and has been given by some physicians internally. If it be indeed rendered milder by this inflammation of spirit of wine, the effect must be produced by a partial reduction of the mercury, occasioned by some phlogiston which it receives from the spirit of wine; but the internal use of this precipitate is abolished, because the effects of other preparations are more uniform and certain.

Red precipitate is much less volatile than crude mercury. Nevertheless, by a strong fire in close vessels it may be sublimed entirely, and the sublimate has the same color and other qualities as the precipitate. As nitrous acid is a very powerful agent to deprive bodies in general, and particularly metallic substances, of part of their phlogiston; and as red precipitate has all the appearance of a mercury partly deprived of its inflammable principle; I have endeavored to calcine it further by leaving it exposed a long time to fire, and by dissolving it many times in fresh nitrous acid. For this purpose I digested during four days some red precipitate with a strong heat, which I then dissolved in more nitrous acid, afterwards restored it to the state of red precipitate, and then calcined it again during four days. Eight times I repeated these calcinations and solutions: but when I examined my mercury, it appeared to be just the same as it was after the first solution and calcination. This determined me to relinquish the experiment. It proves, that if the nitrous acid does deprive the mercury of any of its phlogiston, the quantity of this principle is very small which it thus detaches, and is only that which is but little adherent and superabundant. It also proves, that nitrous acid takes as much phlogiston from the mercury the first time as it can; and that therefore any attempts to dephlogisticate it perfectly would be unsuccessful by this, or probably by any other method, since this seems to be the most effectual.

Lemeri observes, that many authors have believed that the color of red precipitate might be much heightened by thrice cohobating and distilling the white mass above-mentioned with spirit of nitre; and he affirms, that this effect

is not produced by these operations. This experiment is similar to that I have mentioned, but is less capable of changing the mercury, because it is not calcined after each distillation. I have also remarked, that red precipitate is easily soluble, and produces heat, but no effervescence, with new nitrous acid. Lemeri observed the same phenomenon with vitriolic acid.

DLXIII. PRECIPITATE (GREEN); *and* PRECIPITATE (BLACK), *or* VIOLET-COLORED MERCURY. Some authors, particularly Lemeri, give processes for other preparations of mercury, which have been employed as remedies, and which are improperly called *precipitates*. Such is green precipitate, which is a mixture of four parts of mercury and one part of copper, dissolved separately in the nitrous acid, and treated as in the process for making red precipitate; afterwards, partly dissolved a second time by being digested with vinegar; and, lastly, reduced by evaporation to a dry consistence. Such also is the preparation called by Lemeri *violet mercury*, or *black mercurial panacea*, or *black precipitate*, which is an artificial cinnabar overcharged with sulphur, mixed with sal ammoniac, and prepared by a very long and laborious process: but as these preparations have been made only for the use of medicine, and have fallen into disrepute, we shall not say any more of them, excepting that they are singular mixtures, accompanied with many unforeseen appearances, which could not be explained without further examination and particular dissertations. *See the article* MERCURY *for the medicinal virtues of all the mercurial preparations called precipitates.*

DLXIV. PRECIPITATE *of* GOLD *by* TIN, *or* PURPLE POWDER *of* CASSIUS. This precipitate of gold may be made by several methods: but which of these is the best, has not yet been decided. The cause of this uncertainty is, that the preparation requires delicate management, and is uncertain in its result, the beauty of the color seeming to depend on some small circumstances not yet discovered; for we find that the color of the powder obtained frequently varies, notwithstanding the processes seem to have been the same. I have tried several methods. The following is what has best succeeded with me, and is nearly the same as that described by Mr. Gellert in his Metallurgic Chemistry.

Make an aqua regia with two parts of spirit of nitre and one part of spirit of salt; dilute this acid with an equal quantity of distilled water; add to it a small piece of Malacca tin, and let it be dissolved without heat. If the weather be cold, the time employed in this solution will be long; but this is rather an advantage than an injury. When this piece of tin is entirely dissolved, add another, and let it be dissolved in the same manner; continue to add more pieces of tin, one at a time, till the liquor has acquired a yellow color, and almost ceases to act upon the tin; then decant the liquor from the remaining piece of metal.

Also dissolve gold of 24 karats in an aqua regia composed of three parts of spirit of nitre, and one part of spirit of salt. This solution may be accelerated by the heat of a sand-bath.

Dilute the solution of tin in a hundred times its quantity of distilled water. Try your solutions in the following manner: Take a small quantity of the diluted solution of tin; divide it into two parts; to one of which add a known

quantity of diſtilled water: to each of theſe portions of the ſolution of tin add a drop of the ſolution of gold, by which they will acquire a red purple color: obſerve which of the colors of the two ſolutions is the fineſt, and keep to that degree of dilution for the reſt of the ſolution of tin: to the ſolution of tin thus diluted add ſuch a quantity of the ſolution of gold, that there ſhall be in the mixture two parts of the former metal to one of the latter: ſtir well the mixture (which ought to be made in a large glaſs veſſel) with a glaſs rod. The whole will acquire the color of red wine, and a ſediment will gradually be depoſited of the ſame color, while the liquor will become clear. Then pour into this clear liquor ſome drops of the ſolution of tin, and obſerve if any more gold is precipitated: when the liquor is very clear, decant it gently from the ſediment, which is to be well waſhed with pure diſtilled water. This is precipitate of gold, or the purple powder diſcovered by Caſſius. It is a valuable preparation, becauſe it is the only one known capable of giving a red purple or crimſon color to glaſs, enamel, and porcelain. When it is to be uſed, it muſt be well mixed, and ground with a fuſible glaſs, as Venice glaſs; and this mixture is to be expoſed to the degree of heat neceſſary for melting the glaſs. If a colored glaſs or artificial ruby be required to be made, ſo large a quantity of glaſs is to be added to the mixture that the gold ſhall not deſtroy its tranſparency: but for enamel painting, a ſmaller quantity of glaſs is required, that the color may be intenſe. The particular proportions cannot be aſcertained, becauſe the intenſity of the color given by the gold is very variable.

We have already remarked, that this preparation is ſubject to varieties; and that by the ſame proceſs it is ſometimes more and ſometimes leſs beautiful. Sometimes we can obtain only a precipitate of a black violet color; at other times we can obtain ſcarcely any color, without being able to diſcover the reaſon of theſe differences. We know, however, many eſſential circumſtances concerning the ſucceſs of the operation. We are certain, that little or no purple precipitate will be formed when the tin has been quickly diſſolved, and with heat and efferveſcence. To underſtand the reaſon of this, we muſt recollect the following principles.

Firſt, the gold is really precipitated in this experiment; for the purple powder may be reduced to gold. Beſides, we know that this metal, when much divided and united with ſome ſaline parts, or perhaps even with a ſuperabundant quantity of phlogiſton, has always a reddiſh-purple or violet color.

Secondly, the gold is here precipitated only by means of the tin; becauſe this latter metal has a ſtronger affinity than the former with the acids of aqua regia; and although it already is united with the ſame acids, it yet ſeizes thoſe ſuperabundantly that keep the gold diſſolved, which it therefore precipitates. This propoſition is proved by obſerving, that nothing elſe is added to the ſolution of gold in the preparation of the purple powder, than tin, aqua regia, and water; but as no quantity of aqua regia and water can occaſion this precipitate, the tin therefore is the ſubſtance which does occaſion it. Beſides, gold may be formed into a purple precipitate by adding a piece of tin to a ſolution of gold in aqua regia. If a queſtion be aſked, Why, when we employ a ſolution of tin, that is, tin united with ſo much acid that it remains diſſolved in much water, this tin ſhould nevertheleſs ſeize upon the acids which keep the gold diſſolved? the reply is, That tin is capable of charging itſelf with a

larger quantity of acid than is neceſſary to diſſolve it; and alſo, that when its ſolution is diluted in a large quantity of water, more acid is required to keep the metal diſſolved: for when a great deal of water is added to a clear ſolution of tin, the liquor will become turbid, and the tin will be precipitated. We cannot then be ſurprized that the tin, which in this dilute ſolution is on the point of precipitating before the ſolution of gold is mixed with it, and which then has ſcarcely a ſufficient quantity of acid to keep it diſſolved, ſhould, when that mixture is made, ſeize the acids of the ſolution of gold.

Thirdly, we know that metals are capable of being diſſolved in acids by means of their phlogiſton. We know alſo that acids, and particularly the nitrous, take from the imperfect metals a part of their phlogiſton during the ſolution of theſe metals, and that this loſs of phlogiſton ſuſtained by metals is ſo much more conſiderable as the ſolution is made with more activity, quickneſs, and heat. Tin is more ſubject to loſe its phlogiſton than any other metal; hence it cannot continue ſuſpended in the nitrous acid, which takes ſo much of its phlogiſton from it, that it is ſoon reduced to a white calx: although the marine acid, a large quantity of which is in the ſolution of tin employed for the preparation of the purple powder of Caſſius, conſiderably moderates the action of the nitrous acid, and prevents ſo compleat a dephlogiſtication as is occaſioned by pure nitrous acid; nevertheleſs, when this ſolution is performed with too much activity, the tin is too much calcined, part of it is often precipitated in form of a white calx, and the remaining part which is diſſolved contains ſo little phlogiſton, that the acids of the ſolution of gold cannot act properly upon it: hence ſuch a ſolution of tin is unfit for the preparation of the purple precipitate of Caſſius, and it frequently is incapable of forming it: hence we ſee the reaſon why the ſucceſs of the operation depends ſo much on the ſlowneſs with which the tin is diſſolved.

The ſolution of tin muſt be diluted in much water, elſe a fine color will not be produced. The reaſon of this is, that the tin is ſo much more capable of precipitating the gold, as by the dilution of the acids with which it is united, it is more diſpoſed to fall down ſpontaneouſly. Accordingly, a certain quantity of tin is always precipitated along with the gold, which appears in form of a white calx.

The ſolution of tin in aqua regia is not the only ſubſtance with which a purple powder of gold may be made. We have already ſeen, that a ſmall piece of tin put in a dilute ſolution of gold forms a purple precipitate. Orſchal mentions this and ſeveral other very curious experiments on the ſame matter, in his little Treatiſe called *Sol ſine Veſte*. For inſtance, we there find that the ſmoking liquor of Libavius makes alſo a purple precipitate. I have found that tin diſſolved in marine acid likewiſe makes it. The ſame chemiſt further ſays, that a ſolution of mercury in ſpirit of nitre mixed with a ſolution of gold produces a more beautiful precipitate than tin; that fulminating gold, that gold itſelf when much divided, like the powder ſcraped off a piece of gold by pounceſtone, being mixed and melted with vitreous matters, make a red glaſs. Theſe facts prove, that this color is natural to gold, whenever it is very much divided.

This purple powder appears to have been a ſecret and a novelty in the time of Orſchal; as he ſays that he learnt it from Caſſius himſelf. Several cotemporary

porary chemists believed, that the gold was decomposed in this operation, and vitrified in the red glass which received its color from it: but Orschal, less disposed to the marvellous, because he was more intelligent, remarks, that the gold is not decomposed, and only is less easily reducible than when under another form; which is a true explanation. *See* TIN *and* GOLD. (*f*)

DLXV. PRINCIPLES. This name is given to substances obtained from compound bodies, when their analysis or chemical decomposition is made.

Philosophers and chemists have long ago discovered, that almost all natural bodies are capable of being reduced to a greater or less number of other bodies less compounded, similar to each other, and almost the same, of whatever nature the body was from which they were separated. This important observation has induced a belief, that the innumerable productions of nature were only the results of the combination of a few more simple substances, the different proportions and arrangements of which formed the diversity of all compound bodies. These last bodies retain the name of *compounds*; and the more simple substances, from the union of which these compounds result, are called *principles*: but as the number and nature of the principles of bodies can only be discovered and ascertained by many laborious chemical experiments, and as in these latter times only, chemistry has been properly cultivated as a part of natural philosophy, ancient philosophers could only give vague conjectures concerning the number and nature of the principles of bodies. Accordingly,

(*f*) Long cylindrical pieces of glass, called *Jews glass*, are commonly sold, and much used by manufacturers of glass-toys. This glass, though perfectly colorless, yet when it is exposed to the heat and flame of a lamp, acquires a beautiful ruby color, exactly similar to that of pure glass melted with powder of Cassius. As no other known substance but gold gives that color to glass, we may presume that this glass contains some of that metal; in which case, the gold appears to be vitrified, and more changed than in any other known preparation of it. Kunkel says, that having occasion frequently to make this ruby glass, he had sometimes observed the glass, when taken out of the crucible, instead of being colored as usual, to appear colorless as crystal, and to acquire a ruby color by exposure to the flame of a lamp.

Dr. Lewis observes, that though a purple or a ruby color may easily, by the methods published, be applied upon glass or enamels, and introduced into the mass by fusion, the way of equally diffusing such a color thro' a quantity of fluid glass is still a secret. That author says, that he has made several trials of this kind, in one of which the glass was uniformly tinged of a ruby color; and in the others various colors, as yellow, red, and brown, appeared, and were unequally diffused: but he had not discovered the circumstances upon which these differences depend. Orschal, in his Treatise *Sol sine Veste*, gives a process by which he obtained a fine ruby glass. He directs, that the powder of Cassius should be ground with six times its quantity of Venice glass finely powdered; and that this mixture should be well mingled with a fritt consisting of equal parts of borax, nitre, and fixed alkaline salt, and four times as much calcined flint as of any of the salts: but he does not mention the proportion of the powder of Cassius to the fritt, nor in what manner the fusion is to be performed.

Kunkel says, that one part of the powder of Cassius is sufficient to give a ruby color to twelve hundred and eighty parts of glass.

Dr. Franklin observes, that gold-leaf placed betwixt two plates of glass being exposed to an electrical shock, stained the contiguous glass with red spots, which were sunk into the body of the glass.

ingly, in each ſchool of philoſophy different opinions prevailed concerning theſe principles, ſome of them admitting one only, and others more: ſome aſſerting that water was the principle of all things; ſome contending for earth, and others for fire. We do not intend to diſcuſs all theſe opinions; but ſhall only obſerve, that almoſt all the ancient philoſophers have been miſtaken from a want of a ſufficient number of chemical experiments and obſervations.

The chemiſts of the middle ages, that is to ſay, about the time of Paracelſus, had very confuſed notions concerning this matter. They admitted five principles of bodies, which they called *mercury* or *ſpirit*, *phlegm* or *water*, *ſulphur* or *oil*, *ſalt*, and *earth*. By *mercury* they probably meant whatever is volatile, and which in the analyſis of bodies is capable of affecting the taſte and ſmell. This conjecture is confirmed by the name *ſpirit*, which they alſo gave to the ſame principle. Their *phlegm* comprehends all the watery uninflammable products obtained in the analyſis of bodies. By *ſulphur* they meant not only ſulphureous matters and common ſulphur, but alſo any oils, and all the inflammable matters obtained in the decompoſition of bodies. All ſaline matters obtained in theſe analyſes were comprehended under the general name *ſalt*. Laſtly, they applied the word *earth* to the fixed matters which remain after the analyſis of bodies. We ſhall afterwards ſee that ſome of theſe principles, which are called the principles of Paracelſus, are ſimpler than others; hence obſcurity and confuſion have been introduced into the opinions formed concerning principles in general.

Beccher, perceiving this inconveniency in the principles of Paracelſus, attempted to reduce their number, and to give more preciſe notions of them. He eſtabliſhed only two general principles of all bodies, namely, water and earth: but as he could not explain the properties of all compounds from theſe two principles, he admitted three kinds of earths, which he conſidered as equally ſimple and elementary. The firſt he called *vitrifiable earth*, which, according to him, is the principle of the fixity, of the ſolidity, and of the hardneſs of bodies. He called his ſecond earth *inflammable earth*, which he ſuppoſes to be the principle of inflammability of all inflammable bodies. Laſtly, the third earth of Beccher is called *mercurial earth*. He conſidered this earth as forming with the two others metallic ſubſtances, and he alſo admitted it as a principle in the compoſition of other bodies, particularly of the marine acid. This chemiſt gave the name *earth* to theſe three laſt mentioned principles, becauſe he conſidered them as being of a dry nature, and as differing eſſentially from water, which he conſidered as a principle eſſentially humid.

The theory of Beccher concerning principles is very profound, and may be conſidered as the ſource of the moſt important diſcoveries of modern chemiſtry: but we muſt confeſs, that had not the illuſtrious Stahl commented upon this theory, illuſtrated and extended it, we might have received no benefit from it.

This excellent chemiſt eaſily ſhewed, that water and vitrifiable earth enter as elements into the compoſition of many bodies; for theſe two principles are ſenſible, and all the experiments of chemiſts ſhew their exiſtence in moſt compounds: but the other two principles of Beccher, namely, his mercurial earth and his inflammable earth, have not, even yet, been expoſed to our ſenſes, ſingle and pure; and therefore all the ſagacity and genius of Stahl were required to demonſtrate the exiſtence and properties of this inflammable earth, which

which we now call *phlogiston*, or *inflammable principle*, and which is nothing else than the very substance of fire when rendered a principle of bodies. *See* PHLOGISTON.

The existence of the mercurial earth is not satisfactorily demonstrated either in the works of Beccher or of Stahl. We have nothing but inferences and presumptive proofs of its existence. *See upon this subject* METALS *and* METALLISATION.

That earth, water, and fire enter into the composition of bodies as principles, may be considered now as demonstrated by Beccher and Stahl. The experiments of many philosophers and chemists, particularly Boyle and Hales, have shewn that air also enters into the composition of many bodies as a principle, and even in very large quantities. Thus if we add this fourth principle to the three others above-mentioned, we shall find to our surprize, that we now admit as principles of all compounds the four elements, fire, air, water, earth, which Aristotle taught were such, long before the knowledge of chemistry was sufficient to establish this truth.

In whatever manner bodies are decomposed, we always obtain these substances. They are the utmost limits of chemical analysis. As we cannot by any means decompose these further, we consider them as simple substances, (although perhaps they may not be so) and are therefore called *primary principles* or *elements*. *See* ELEMENTS, AIR, EARTH, FIRE, WATER, PHLOGISTON.

When we decompose most bodies, we cannot nearly reduce them to their elements or primary principles by a first analysis, especially when they are much compounded. We obtain from them substances more simple only, but still compounded of other principles, for a reduction to which another analysis is requisite. As these substances, although compounded of a certain number of principles, do themselves the office of principles in the composition of bodies less simple than themselves, they have been called *principiate principles*. The principiate principles have so much better title to this name, as they subsist in their state after they have been separated from a body, characterised by peculiar properties, unalterable but by a new analysis, and capable of reproducing by their union a compound entirely like that from which they were originally separated. Most chemical agents, as acids and alkalis, are of this kind.

In the analysis of very compound bodies, principiate principles of different degrees of simplicity, or rather such as are capable of being reduced to others more and more simple, may be thus obtained successively, by first, second, and third analyses: hence several kinds of principiate principles of different degrees of simplicity, and which consequently are, by a true gradation, principles of one another, have been distinguished. Modern chemists distinguish them by names which mark their order of composition. Thus substances which cannot be further decomposed, and which are considered as simple, are called *primary principles*. *Secondary principles* are those which result immediately from the union of primary principles. *Principles of the third order* are those which are composed of secondary principles; and so on.

We may also with propriety distinguish the principles of bodies by the names of *proximate principles* and *remote principles*, by applying the former name to the principiate principles obtained directly from a body by a first analysis, and by

by applying the latter name to the principles obtained by a further decompoſition of theſe proximate principles.

Theſe diſtinctions will be rendered more intelligible by an example; for the ſubject of which let us chuſe a neutral ſalt, ſuch as nitre. We have demonſtrated that this ſalt is a compound of the acid called *nitrous*, and of the fixed vegetable alkali, combined and ſaturated together. By a firſt analyſis then of nitre we ſhall obtain this acid and this alkali, which are therefore the proximate principles of nitre. But neither nitrous acid nor fixed alkali are ſimple ſubſtances. By a further analyſis of each of theſe, they may be decompoſed into water, earth, fire, or inflammable principle. This acid and this alkali muſt then be conſidered as *principiate principles*. But as the ſubſtances obtained from them are unalterable, and cannot be further decompoſed, they muſt be conſidered as *primary principles*; the acid and the alkali of the nitre are then immediately compoſed of primary principles, and they themſelves are conſequently principiate principles, or ſecondary principles, or *principles of the ſecond order*. In this example the water, earth, and fire, are the remote principles of the nitre.

Altho' theſe ſeveral denominations and diſtinctions of principles more or leſs ſimple be juſt and uſeful for the illuſtration of many important points in the theory of chemiſtry, this ſcience is not however ſufficiently advanced to enable us to determine the number and kinds of principiate principles of different orders, and eſpecially of the higher orders. We know but a few, which, we have ſtrong reaſons to believe, belong to the ſecond order; ſuch, for example, are ſaline ſubſtances, and the more ſimple acids and alkalis; but we are not entirely certain of this, becauſe we have not been able to produce any of theſe ſubſtances from the union of the primary principles, in ſuch a manner, that no doubt can be admitted. *See the articles* COMBINATION, ANALYSIS, DECOMPOSITION.

DLXVI. PUMICE-STONE. (g)

DLXVII. PURIFICATION. By purification is meant any chemical operation by which ſubſtances required to be obtained pure and ſingle are ſeparated from other heterogeneous matters with which they happen to be mixed.

As the ſeveral chemical agents and other matters are generally more or leſs confounded, and even combined with ſubſtances of different natures, and as we require in many accurate experiments that they ſhould be very pure, we muſt therefore apply the proper methods to give them the neceſſary degree of purity.

But theſe methods differ very much according to the nature of the ſubſtance to be purified. They muſt be appropriated to their peculiar natures, and alſo to the nature of the ſubſtances to be ſeparated. For the ſeveral purifications, we are obliged to employ almoſt all the operations of chemiſtry. Hence many operations are only true purifications, altho' they are not ſo called. For inſtance, all the ſecond diſtillations and ſublimations called *rectifications*, are nothing elſe than purifications. They are employed for the purification of volatile ſub-

(g) PUMICE-STONE is a light, porous, ſpongy ſtone, reſembling the ſcoria of furnaces. Its colors are white, yellowiſh, brown, or black. It is found near volcanos, and is believed to be a ſubſtance reduced to a burnt or ſemi-vitrified ſtate by ſubterranean fires. Wallerius conjectures that it is the aſhes of foſſil coals thus changed by fire. Pumice-ſtone is fuſible by intenſe heat.

ſtances

ſtances from others that are fixed, or leſs volatile. In this claſs may be ranged the rectifications of oils, of volatile ſpirits and ſalts, of ardent ſpirits, and even of mineral acids; and the ſublimations of ſulphur, of arſenic, of cinnabar, of ſalt of amber, of flowers of benjamin, and of ſal ammoniac. *See* Rectification *and* Sublimation. Alſo the repeated ſolutions, filtrations, evaporations, and cryſtallizations of neutral ſalts are only means of purifying them. *See* Crystallization, *and* Salt (Neutral). Several calcinations, and particularly thoſe of fixed alkalis, are intended merely to purify them, by depriving them of a greaſy matter or ſuperabundant inflammable principle. *See* Calcination, *and* Alkali (Fixed). Many ſolutions and precipitations by the humid way, particularly in the operations of parting, and of luna cornea, are performed for the purification of the perfect metals from their allay. Laſtly, the repeated fuſions of metallic ſubſtances, the ſmelting of ores, cupellations, and refining, are true purifications of metallic matters. Amongſt all theſe operations, but a very few are called *purifications:* ſuch as the purification of ſilver by nitre, of gold by antimony; of both which we ſhall now treat.

DLXVIII. PURIFICATION *of* SILVER *by* NITRE. The ſilver to be purified by nitre is to be firſt granulated, and then mixed with a fourth part of its weight of dry nitre, an eighth part of potaſh, and a little common glaſs, all in powder. This mixture is to be put into a good crucible, two-thirds of which only muſt be full. This crucible is to be covered with a ſmaller crucible inverted, and luted to the former, and in the bottom of which a ſmall hole has been made. The crucibles thus diſpoſed are to be placed in a furnace, capable of drawing air ſufficiently to make the fire intenſe enough only to melt the ſilver. Then charcoal is to be put into the furnace to ſuch a height, that only the top of the inverted crucible ſhall be uncovered. The coal is then to be kindled, and the veſſels to be made moderately red: a hot coal ought to be put upon the ſmall hole in the bottom of the inverted crucible. If a ſhining light be obſerved round this coal, and a ſlight hiſſing noiſe be at the ſame time heard, we may know that the operation proceeds well. The fire muſt be ſuſtained at the ſame degree, till theſe appearances ceaſe; when it muſt be encreaſed ſo that the ſilver be well melted, and then the crucibles are to be taken out of the furnace. The larger crucible is to be broken when it is cold, and the ſilver will be found at the bottom covered with a green alkaline ſcoria. If the metal be not ſufficiently pure and ductile, the operation muſt be again repeated.

This operation is founded on a property which nitre has of effectually calcining all imperfect metals, by burning their phlogiſton; and alſo upon a property of calcined metals, by which they cannot be united with others in their metallic ſtate. This being eſtabliſhed, when ſilver allayed with copper or other imperfect metals is to be treated with nitre, this ſalt quickly calcines theſe imperfect metals by detonating with their inflammable principle; and they are no ſooner calcined, than they are rendered incapable of remaining united with the ſilver. Theſe metallic calxes being alſo ſpecifically lighter, riſe above the ſilver, where they meet the alkaliſed nitre and potaſh, with both which they form a ſcoria. The ſilver being capable of reſiſting the action of the nitre, is thus diſengaged from its allay, is fuſed, and collected at the bottom of the crucible.

As the purification of ſilver is effected by the detonation of nitre with the imperfect metals, and as this detonation is always accompanied with ſwelling and efferveſcence, the crucibles muſt not be too firmly cloſed, otherwiſe this efferveſcence might break them, and ſome of the contained matter might be loſt: therefore a ſmall hole is left in the upper crucible, which ſerves as a cover to the other; beſides, the empty ſpace left in the veſſels thus diſpoſed, allows the matter contained to ſwell a little without loſs.

This ſmall hole is alſo very uſeful to ſhew the proper degree of fire during the operation, as has been ſaid. The light and the hiſſing noiſe, which may be perceived when a coal is applied, are occaſioned by part of the nitre which is raiſed up undecompoſed during the detonation. When theſe effects are too conſiderable, and that a ſenſible hiſſing may be heard at the ſmall hole, even when a hot coal is not applied to it, we may know that the detonation is too violent. In that caſe the fire muſt be leſſened, otherwiſe much of the nitre would be carried off, and together with it, ſome part of the ſilver, which would be loſt. And even, notwithſtanding all the precautions that can be uſed, this operation can ſcarcely be performed without ſome loſs of the ſilver. Small grains of ſilver are always to be ſeen in the upper crucible, and about the ſmall hole in it. This inconvenience prevents the operation from being employed to determine the value of ſilver, for which purpoſe *cupellation* is therefore uſed.

The purification of ſilver by nitre, has nevertheleſs its peculiar advantages in ſome circumſtances. It is more quick and expeditious than cupellation, and the loſs of ſilver is not conſiderable, when all the proper attentions are obſerved. *See* SILVER, NITRE, *and* DETONATION *of* NITRE.

DLXIX. PURIFICATION *of* GOLD *by* ANTIMONY.

To purify gold from its allays by antimony, the gold is to be melted in a crucible large enough to contain thrice the quantity of metal. When the gold is melted, twice its weight of crude antimony powdered is to be thrown upon it; the crucible is to be covered, and the matter left ſome minutes in fuſion: after which, when the mixture is well fuſed, and ſo hot that its ſurface ſparkles, it is quickly to be poured into an iron cone, previouſly heated and greaſed. By ſtriking the cone againſt the ground, the deſcent of the regulus will be aſſiſted; and when the cone is cold, it is to be inverted, and the matter taken out. This matter conſiſts of two ſubſtances; the upper one of which is compoſed of the ſulphur of the antimony united with the metals with which the gold was allayed, and the lower is the gold united with a quantity of the regulus of antimony proportionable to the quantity of metals which have been ſeparated from the gold, and which are now united with the ſulphur of the antimony. This regulus of gold may be ſeparated from the ſulphurated metals which cover it; and will be found to be ſo much leſs yellow, that is, mixed with ſo much more regulus of antimony, as the gold was more allayed.

As a ſingle fuſion is not generally ſufficient to diſengage the gold from all its allay, it ought to be fuſed again in the ſame manner, and with the ſame quantity of antimony, and even a third time, if the gold was much allayed. It is fuſible with leſs fire the ſecond and third time than the firſt, from the regulus of antimony which is united with it.

This firſt part of the purification of gold by antimony is founded on a property of ſulphur, by which it is incapable of uniting with gold, and is ſtrongly diſpoſed to unite with all other metallic ſubſtances excepting platina and zinc; and alſo upon this property of ſulphur, that it has leſs affinity with regulus of antimony than with any metallic ſubſtance with which it can unite. Hence, when gold allayed with ſilver, copper, iron, lead, &c. is melted together with crude antimony, theſe latter metals unite with the ſulphur of the antimony, while the reguline part, diſengaged by them from its ſulphur, unites with the gold. The ſeparation of metals from gold is then really occaſioned by the ſulphur of the antimony. This purification of gold is conſequently a kind of *dry parting*, but it ſucceeds better than the dry parting by ſulphur alone. The reaſon of this difference is, that ſulphur being very volatile and inflammable, is in great meaſure diſſipated and conſumed, when it is employed alone, before it can ſeize the metals allayed with the gold; whereas when it is already united with a metallic ſubſtance, as it is in the antimony with the reguline part, which prevents it from being quickly conſumed and diſſipated, it may be much more eaſily applied to the metallic ſubſtances allayed with gold. Notwithſtanding this advantage, as a quantity of regulus of antimony is always united with the gold, proportionable to the quantity of metallic ſubſtances ſeparated by means of the ſulphur of the antimony; and as the ſeparation of this regulus from the gold requires much time, as we ſhall ſoon ſee; therefore, when we would purify gold that is much allayed, ſuppoſe under 16 karats, we ought to add along with the antimony ſome pure ſulphur, that we may have a leſs quantity of regulus to ſeparate afterwards from the gold.

When theſe firſt fuſions have been well made, the gold obtained is allayed with only regulus of antimony. But as this ſemi-metal is very volatile and very combuſtible, it may be ſeparated from the gold by a ſufficiently long expoſure to the action of fire. For this purpoſe, the regulus of gold obtained by the former operation is to be put into a large crucible, and heated ſufficiently to keep it in good fuſion. With this heat, the antimony will be diſſipated in ſmoke. If the heat be too ſtrong, ſome of the gold will be carried off with the antimony. The operation therefore muſt be performed ſlowly; and it continues a long time, when much of the regulus of antimony is united with the gold; but it may be abridged by blowing on the ſurface of the metallic maſs, becauſe the application of freſh air accelerates the evaporation of all bodies, and particularly that of the regulus of antimony. When a part of the regulus is diſſipated, more heat is required to keep the metal fuſed, and therefore the fire muſt be encreaſed towards the end of the operation: beſides, when only a ſmall quantity of regulus of antimony remains, it is ſo covered by the gold, and protected from the action of the fire and air, that a ſtronger heat is neceſſary to evaporate it. The ſmoke ceaſes entirely towards the end of the operation, although ſome regulus ſtill remains united with the gold. The purification is compleated by means of a little nitre thrown into the crucible, which effectually calcines the remaining regulus of antimony Sometimes after theſe operations, the gold is found to be deprived of much of its uſual ductility, which however is eaſily reſtored to it by fuſing it with nitre and borax.

The ancient chemiſts called antimony the *balneum regis*, or the *balneum ſolis*, and the *lupus metallorum*, from this property which it poſſeſſes, of purifying gold. The ſulphur of this mineral does, indeed, ſeize almoſt all the metals with which gold can be allayed; but theſe metals are not deſtroyed, but only reduced to a ſort of mineral ſtate by the ſulphur, forming the ſcoria, from which they may be obtained. Therefore, when the gold contained much allay of ſilver, the ſcoria is very valuable, ſince it contains all the ſilver which was united with the gold. This ſcoria ought to be preſerved and treated like an ore of ſilver, and thus the metal extracted from it. *See* ESSAYS, *and* SMELTING *of* ORES. *See alſo* ANTIMONY, GOLD, SULPHUR.

DLXX. PUTREFACTION. Putrefaction is an inteſtine motion or fermentation excited in the proximate principles of vegetables and animals, by which a decompoſition and total change of the nature of theſe principles are produced, and an alkaline quality is given to the ſaline principles of the compound bodies which ſuffer it.

As putrefaction is a true fermentation, and even is the termination and ultimate degree of all fermentations, therefore all vegetable and animal matters which are fermentable, are alſo capable of putrefaction. Some matters are ſuſceptible of putrefaction only, and not of the two previous degrees of fermentation, namely, the ſpirituous and the acid fermentations. Theſe matters have either already ſuffered the two previous degrees of fermentation, or their principles are diſpoſed by nature in the ſame manner as if they had already ſuffered theſe fermentations: moſt ſubſtances perfectly animaliſed are of this kind.

When fermentable matters of this kind contain a ſufficient quantity of water, when they are expoſed to a ſuitable degree of heat, and have all the requiſite conditions for fermentation in general, they never fail to ſuffer putrefaction. The phenomena accompanying this laſt degree of fermentation are nearly the ſame as thoſe of the two former degrees, excepting that they are leſs ſenſible, at leaſt when the putrefaction proceeds ſlowly. But this ſubject has not been ſufficiently attended to. Mr. Beaumé affirms, that putrefaction is not accompanied with any ſenſible heat. When indeed the putrefaction proceeds ſlowly, and the quantity of putrefying matter is but ſmall, the heat, if any, is very little; but the moſt ſudden and remarkable changes produced upon a body by putrefaction, are upon its color, ſmell, and taſte. Fleſh beginning to putrefy is well known to exhale very ſoon a penetrating fetid ſmell, its color to become livid and black, and its taſte nauſeous. Tranſparent liquors, as urine and broth, during putrefaction, become alſo turbid. As the putrefaction advances, the ſmell becomes more and more fetid, but it alſo acquires great pungency. This pungent ſmell of putrefying matters is very ſenſible in houſes of office, when the weather is changing, particularly before a froſt. This pungency is ſometimes ſo conſiderable that it excites coughing, and draws tears from the eyes. It is cauſed by a large quantity of volatile alkali, which is diſengaged when theſe ſubſtances are completely putrified.

Solid bodies, while they are putrefying, ſwell, become ſoft, loſe the coheſion of their parts, and are laſtly reduced to a very diſguſtful liquor.

From

From matters completely putrefied may be obtained by diſtillation volatile alkali, ſome liquid and ſome ſolid; pungent, fetid oil, which at firſt is thin, and afterwards becomes more thick; and a reſiduum of coal not eaſily reducible to aſhes. Moſt chemiſts affirm that no fixed alkali is obtained from matters which have undergone a compleat putrefaction; but Mr. Beaumé aſſures us that theſe matters contain fixed alkali ready formed, which may be obtained without fire. This matter requires a more particular examination; perhaps ſeveral ſtages of putrefaction are attended with conſiderable differences in this reſpect.

From the hiſtory of putrefaction we may ſee that this laſt degree of fermentation alters entirely the nature of ſubſtances which ſuffer it, whatever the qualities of their proximate principles may be. By putrefaction they loſe their diſtinctive properties, as they are all converted into volatile alkali, fetid oil, and earth: their organization is deſtroyed, their veſſels, fibres, cells, the very texture of the moſt ſolid parts, are changed, disjoined, and entirely reſolved. All theſe changes are ſpontaneouſly produced upon organized bodies as ſoon as their vital motion ceaſes. As ſoon as vegetables and animals die, nature completes their deſtruction, decompoſes machines now uſeleſs, reduces their materials to a ſimilar and common ſtate; elaborates them again, ſo as to fit them to paſs into the organization of other beings, which alſo muſt afterwards undergo the ſame changes. Thus by an uninterrupted courſe of operations, nature inceſſantly renews the life of beings, which, notwithſtanding the old age and deaths of individuals, is ſuſtained in perpetual vigor and youth, as has been obſerved by one of our moſt eloquent modern philoſophers.

We have already remarked that the nature and phenomena of putrefaction have been but too little examined hitherto. We ſhall add here, that whatever attention may be given to this ſubject, we ſhall perhaps be never able to know more than the beginnings of this operation, and even a ſmall part only of theſe. In fact, putrefaction ſeems to be a very extenſive operation, and its laſt ſtage ſeems in ſome meaſure out of our reach. We conſider that a matter is entirely putrefied, when nothing remains but earth, or the fixed parts of it. But theſe coarſe materials are the leaſt part of thoſe which compoſe organiſed bodies. The exiſtence even of theſe reſiduums deprived of all other principles, the volatility of the ſaline and oily principles which are continually exhaling and diſſipating during putrefaction, ſhew that nature is inceſſantly, during this operation, attenuating, ſubtilizing, volatilizing, and carrying off all it can of theſe bodies; and all the ſubſtances, thus elaborated and carried off, are removed from the reach and obſervation of our ſenſes. We do not know, and probably we never ſhall know, what further changes they ſuffer, before they enter into the combination of new beings.

But if the compleat theory of putrefaction be very difficult, it is alſo very important, as it ſeems to be the true key of the moſt eſſential and hidden ſecrets of the animal economy. In fact, as the proper ſubſtance of all the parts of the bodies of animals differs from vegetable matters, (by which all animals are mediately or immediately nouriſhed) in this circumſtance, that they are much nearer the ſtate of putrefaction, we have reaſon to believe that the change of vegetable into animal matters is principally produced by a kind of fermentation, or even by a beginning, ſlow, and imperceptible putrefaction. In this point,

point, certainly, perfect *animalisation* consists; and consequently the animal economy cannot fail of being deranged, and reduced to a morbid state, whenever this animalisation, or imperceptible putrefaction, (for I do not scruple to give it that name) becomes too much or too little: which truth is well perceived by the great Boerhaave in his aphorisms concerning the diseases proceeding from spontaneous acids and alkalis.

These considerations are certainly sufficient to induce chemists and physicians to acquire all the knowledge they can on this subject. The first trials to be made in this way, and from which the greatest certainty and utility may be expected, are researches to shew what substances accelerate and retard putrefaction. Messrs. Pringle and Macbride have made the first steps, and have published the interesting experiments which they have made on this subject, which is very far from being exhausted. I know that a very able French experimental philosopher has finished a numerous set of well made experiments on this subject, which he proposes soon to publish. *See* FERMENTATION. *(b)*

(*b*) To the above article we make the following additions.

1. Putrefaction, as also fermentation in general, seem to consist not merely in the decomposition and transposition of the particles of the putrefying or fermenting matter, by which new combinations are produced, but also in the extrication and expulsion of some of the constituent parts of these matters. The constituent part, thus extricated and expelled by putrefaction and fermentation, is a permanently elastic vapor, or fixable air. A part of the air extracted from putrefying substances was found by Mr. Cavendish's experiments to be inflammable. *See* AIR, (FIXABLE). And from the experiments of Dr. Macbride, which shew that caustic alkali and quicklime may be rendered mild, or combined with air, by absorbing the elastic vapor extricated from putrefying and fermenting substances, we have reason to believe that another part of the vapor extricated from these substances is of the uninflammable kind of fixable air which combines with alkaline salts and earths. *See* AIR (FIXABLE) *and* QUICKLIME.

Dr. Hales believes that this air is the principal cause of cohesion and solidity of bodies. He remarks that air abounds much more in solid than in liquid bodies, and that solid bodies being generally denser than water, the attraction of the air of these solid bodies, in a fixed state, and its repulsion when in an elastic state, are greater than the attraction and repulsion of the lighter watery particles in a fixed and in an elastic state; and hence the particles of air are fitter to be the principal band of union in solid bodies, than the particles of water. That Sir Isaac Newton had entertained a similar opinion, appears from the following passage in the third book of his Optics. "The particles of fluids "which do not cohere too strongly, and are "of such a smallness as renders them most "susceptible of those agitations which keep "liquors in a fluor, are most easily separated and rarefied into vapor, and, in the "language of the chemists, they are volatile, rarefying with an easy heat, and condensing with cold. But those which are "grosser, and so, less susceptible of agitation, or cohere by a stronger attraction, "are not separated without a stronger heat, "or perhaps not without fermentation. And "these last are the bodies which chemists "call *fixed*, and being rarified by fermentation become true permanent air; "those particles receding from one another "with the greatest force, and being most "difficultly brought together, which upon "contact cohere most strongly. And because "the particles of permanent air are grosser, "and arise from denser substances than those "of vapors, thence it is that true air is "more ponderous than vapor, and that a "moist atmosphere is lighter than a dry "one, quantity for quantity."

Dr. Macbride also maintains this opinion, and further endeavors to shew, that without the extrication of this air, no putrefaction can happen, and even that by absorption of it, putrefied substances may be corrected and rendered sweet. Having exposed putrid matters to the vapors arising from fermenting

DLXXI. PYRITES. Pyrites is a mineral resembling the true ores of metals, in the substances of which it is composed, in its color or lustre,

ing mixtures, or from alkaline substances effervescing with acids, he found the putrid quality was destroyed; and hence he considers this air as powerfully antiseptic.

2. Contact of atmospherical air is said to be necessary to putrefaction; and Mr. Boyle relates that he has preserved lemons, oranges, and other fruits, from putrefaction, or other fermentation, during several years, by including them in an inexhausted receiver. Dr. Macbride found that putrefaction was accelerated by enclosing a piece of flesh in an exhausted receiver; but that another piece continued sweet, which was included in an exhausted hollow brass sphere, consisting of two hemispheres joined together. He conjectures that the cause of this difference might be, that in the latter experiment the vacuum was more perfect than in the former, as the glass receiver did not seem to exclude with sufficient accuracy the external air, and that tho' a partial vacuum may accelerate putrefaction, yet some air may be necessary to this process.

It is well known that bodies are preserved from putrefaction by covering them with wax, suet, &c. Whether is this effect produced merely by excluding external air, or also by preventing the extrication of the internal fixable air?

3. Sir John Pringle has made experiments to determine the powers of certain substances to promote or to prevent putrefaction. From these experiments he has formed the following table, shewing the relative antiseptic powers of the saline substances mentioned. Having found that two drams of beef put in a phial with two ounces of water, and placed in a heat equal to 90 degrees of Fahrenheit's thermometer, became putrid in 14 hours, and that sixty grains of sea-salt preserved a similar mixture of beef and water more than 30 hours, he made the antiseptic power of the sea-salt a standard, to which he compared the powers of the other salts. The algebraic character + signifies that the substance to which it is annexed had a greater antiseptic power than is expressed by the numbers.

Sea-salt, or the standard	1
Sal-gem	1 +
Vitriolated tartar	2
Spiritus Mindereri	2
Soluble tartar	2
Sal diureticus	2 +
Crude sal ammoniac	3
Saline mixture	3
Nitre	4 +
Salt of hartshorn	4 +
Salt of wormwood	4 +
Borax	12
Salt of amber	20
Alum	30

N. B. The quantities of spiritus Mindereri and of the saline mixture were such, that each of them contained as much alkaline salt as the other neutral salts.

Myrrh, *aloes*, *assafetida*, and *terra Japonica*, were found to have an antiseptic power 30 times greater than the standard. *Gum ammoniacum*, and *sagapenum*, shewed little antiseptic power.

Of all resinous substances, *camphor* was found to resist putrefaction most powerfully. Sir John Pringle believes that its antiseptic power is 300 times greater than that of sea-salt.

Chamomile flowers, *Virginian snake-root*, *pepper*, *ginger*, *saffron*, *contrayerva root*, and *galls*, were found to be 12 times more antiseptic than sea-salt.

Infusions of large quantites of *mint*, *angelica*, *ground-ivy*, *green tea*, *red roses*, *common wormwood*, *mustard*, and *horse-radish*, and also decoctions of *poppy-heads*, were more antiseptic than sea-salt.

Decoctions of *wheat*, *barley*, and other *farinaceous grains*, checked the putrefaction by becoming sour.

Chalk, and other *absorbent powders*, accelerated the putrefaction, and resolved meat into a perfect mucus. The same powders prevented an infusion of farinaceous grains from becoming mucilaginous and sour.

One dram of *sea-salt* was found to preserve two drams of fresh beef in two ounces of water, above 30 hours, uncorrupted, in a heat equal to that of the human body, or above 20 hours longer than meat is preserved in water without salt: but half a dram of salt did not preserve it more than two hours longer than pure water. Twenty-five grains

of

in its great weight, and, laſtly, in the parts of the earth in which it is found, ſince it almoſt always accompanies ores. It is, like ores, compoſed of metallic ſubſtances, mineraliſed by ſulphur or by arſenic, or by both theſe matters, and of an unmetallic earth intimately united with its other principles.

Notwithſtanding the conformity of pyrites with ores properly ſo called, chemiſts and metallurgiſts diſtinguiſh the former from the latter minerals;

of ſalt had little or no antiſeptic quality. Twenty grains, fifteen grains, but eſpecially ten grains only of ſea-ſalt were found to accelerate and heighten the putrefaction of two drams of fleſh. Theſe ſmall quantities of ſea-ſalt did alſo ſoften the fleſh more than pure water.

The ſame ingenious phyſician made experiments to diſcover the effects of mixing vegetable with animal matters.

Two drams of raw-beef, as much bread, and an ounce of water, being beat to the conſiſtence of pap, and expoſed to 90° of heat, according to Fahrenheit's thermometer, began to ferment in a few hours, and continued in fermentation during two days. When it began to ferment and ſwell, the putrefaction had begun; and in a few hours afterwards, the ſmell was offenſive. Next day the putrid ſmell ceaſed, and an acid taſte and ſmell ſucceeded. Freſh alimentary vegetables, as ſpinnage, aſparagus, ſcurvy-graſs, produced ſimilar effects as bread on fleſh, but in a weaker degree. From ſeveral other experiments he found that animal ſubſtances excite the fermentation of vegetable ſubſtances, and that the latter ſubſtances correct the putreſcency of the former.

By adding *ſaliva* to a ſimilar mixture of fleſh, bread, and water, the fermentation was retarded, moderated, but rendered of twice the uſual duration, and the acid produced at laſt was weaker than when no ſaliva was uſed.

By adding an *oily ſubſtance* to the common mixture of fleſh, bread and water, a ſtronger fermentation was produced, which could not be moderated by the quantity of ſaliva uſed in the former experiment, till ſome *fixed alkaline ſalt* was added, which ſalt was found, without ſaliva, to ſtop ſuddenly very high fermentations.

He did not find that *ſmall quantities* of the following ſalts, *ſal ammoniac, nitre, vitriolated tartar, ſal diureticus, ſalt of hartſhorn, ſalt of wormwood,* were ſeptic, as ſmall quantities of ſea-ſalt were.

Sugar was found to reſiſt putrefaction at firſt, as other ſalts do, and alſo to check the putrefaction after it had begun by its own fermentative quality, like bread and other fermentative vegetables.

Lime-water made ſome ſmall reſiſtance to putrefaction.

Port wine, ſmall-beer, infuſions of *bitter vegetables,* of *bark,* and the juice of *antiſcorbutic plants,* retarded the fermentation of mixtures of fleſh and bread. But an *unſtrained decoction of bark* conſiderably encreaſed that fermentation.

Crabs-eyes accelerated and encreaſed the fermentation of a mixture of fleſh and bread.

Lime water neither retarded nor haſtened the fermentation of ſuch a mixture: but when the fermentation ceaſed, the liquor was neither putrid nor acid, but ſmelt agreeably.

Fleſh pounded in a mortar was found to ferment ſooner than that which had not been bruiſed.

The tough inflammatory cruſt of *blood* was found to be moſt putreſcent, next to which the craſſamentum, or red coagulated maſs, and laſtly the ſerum.

Dr. Macbride's experiments confirm many of theſe above related, eſpecially thoſe which ſhew that the fermentation of vegetable ſubſtances is encreaſed by a mixture of animal or putreſcent matter; that the putreſcency of the latter is corrected by the fermentative quality of the former; and that the putrefaction and fermentation of mixtures of animal and vegetable ſubſtances were accelerated by additions of abſorbent earths and of Peruvian bark: He alſo found that altho' unburnt calcareous earths were ſeptic, quicklime and lime-water prevented putrefaction, but that they deſtroyed or diſſolved the texture of fleſh.

The experiments of the author of the *Eſſai pour ſervir a l'Hiſtoire de la Putrefaction* ſhew that metallic ſalts, reſinous powders, extracts of bark, and opium, are very powerfully antiſeptic, and that ſalts with earthy baſes are leſs antiſeptic than any other ſalts.

and

and they do this with propriety, becauſe the proportion and connexion of the materials compoſing the pyrites differ much from thoſe of ores.

Altho' ſometimes pyrites contains more metal than ſome ores, yet generally it contains leſs metal, and a larger quantity of mineraliſing ſubſtances, ſulphur and arſenic, and particularly of unmetallic earth. The connexion of theſe matters is alſo much ſtronger in pyrites than in ores, and they are accordingly much harder; ſo that almoſt every pyrites can ſtrike ſparks from ſteel. From this property of ſtriking ſparks from ſteel they have been called pyrites, which is a Greek word ſignifying *fire ſtone*. Pyrites was formerly uſed for fire-arms, as we now uſe flints; hence it was called *carabine-ſtone*. It is ſtill named by ſome, *marcaſite*. Perhaps no other kind of natural body has received ſo many names. Perſons curious to know the other names leſs uſed than thoſe we have mentioned, may find them in *Henckel's Pyritologia*. We think, with that celebrated chemiſt, that the ſubject has been perplexed by this multiplicity of names; for before his great and excellent work, the notions concerning pyrites were very confuſed and inaccurate.

Pyrites differs alſo from ores by its forms and poſitions in the earth. Altho' pyritous minerals generally precede, accompany, and follow veins of ores; they do not, properly ſpeaking, themſelves form the oblong and continued maſſes called veins, as ores do, but they form maſſes ſometimes greater and ſometimes ſmaller, but are always diſtinct from each other. Large quantities of them are often found unaccompanied by ores. They are formed in clays, chalk, marles, marbles, plaſters, alabaſters, ſlates, ſpars, quartz, granites, cryſtals, in a word, in all earths and ſtones. Many of them are alſo found in pit-coals and in other bituminous matters.

Pyrites is alſo diſtinguiſhable from ores by its luſtre and figure, which is almoſt always regular and uniform, externally or internally, or both. Some ores indeed, like thoſe of lead, many ores of ſilver, and ſome others, have regular forms, and are in ſome manner cryſtallized; but this regularity of form is not ſo univerſal, and ſo conſpicuous in ores as in pyrites. The luſtre of pyrites ſeems to be cauſed by its hardneſs, and the regularity of its form by the quantity of mineraliſing ſubſtances which it contains.

By all theſe marks we may eaſily, and without analyſis, diſtinguiſh pyrites from true ores. When we ſee a mineral that is heavy, poſſeſſed of metallic luſtre, and of any regular form, the maſs of which appears evidently to be entire, that is, not to have been a fragment of another maſs, and which is ſo hard as to be capable of ſtriking ſparks from ſteel, we may be aſſured that ſuch a mineral is a pyrites, and not an ore.

The claſs of pyrites is very numerous, various, and extenſive. They differ one from another in the nature and proportions of their component parts, in their forms and in their colors. The forms of theſe minerals are exceedingly various. No ſolid regular or irregular can eaſily be conceived that is not perfectly imitated by ſome kind of pyrites. They are ſpherical, oval, cylindrical, pyramidal, priſmatical, cubic; they are ſolids with 5, 6, 7, 8, 9, 10, &c. ſides. The ſurface of ſome is angular, and conſiſts of many baſes of ſmall pyramids; while their ſubſtance is compoſed of theſe pyramids, the points of which all unite in the center of the maſs.

Pyritous minerals differ alſo in their component ſubſtances. Some of them are called ſulphureous, martial, cupreous, arſenical, as one or other of theſe ſubſtances

 predominate.

predominate. We must observe with Henckel, whose authority is very great in this subject, that in general all pyrites are martial, as ferruginous earth is the essential and fundamental part of every pyrites. This earth is united with an unmetallic earth, with sulphur or arsenic, or with both these matters; in which case, the sulphur always predominates over the arsenic, as Henckel observes. He considers these as the only essential principles of pyrites, and believes that all the other matters, metallic or unmetallic, which are found in it, are only accidental; amongst which he even includes copper, although so much of it exists in some kinds of pyrites, that these are treated as ores of copper, and sometimes contain even 50lb. of copper each quintal. Many other metals, even gold and silver, are sometimes combined in pyrites; but these are less frequent, and the precious metals always in very small quantities; they are therefore justly to be considered as accidental to pyrites. The different substances composing pyrites sensibly affect its colors. Henckel distinguishes them in general into three colors, white, yellowish or a pale yellow, and yellow. He informs us, that these three colors are often so blended one with another, that they cannot be easily distinguished, unless when compared together.

The white pyrites contain most arsenic, and are similar to cobalt and other minerals abounding in arsenic. The Germans call them *misspickel* or *misspilt*. Iron and arsenic form the greatest part of this pyrites. As arsenic has the property of whitening copper, some pyritous minerals almost white, like that of Chemnitz, in Misnia, are found to contain forty pounds of copper per quintal, and which are so much whitened by the arsenic, that they are very like white pyrites. But Henckel observes, that these pyritous matters are very rare, and are never so white as the true white pyrites, which is only ferruginous and arsenical.

Yellowish pyrites is chiefly composed of sulphur and iron. Very little copper and arsenic are mixed with any pyrites of this color, and most of them contain none of these two metallic substances. This is the most common kind of pyrites: it is to be found almost every where. Its forms are chiefly round, spherical, oval, flattened, cylindrical, and it is composed internally of needles or radii, which unite in the center or in the axis of the solid.

Yellow pyrites receives its color from the copper and sulphur which enter into its composition. Its color, however, is inclined to a green, but is sufficiently yellow to distinguish it from the other two kinds of pyrites, particularly when they are compared together. To make this comparison well, the pyrites must be broken, and the internal surfaces must be placed near each other. The reason of this precaution is, that the color of minerals is altered by exposure to the air.

Persons accustomed to these minerals can easily distinguish them. The chief difficulty is to distinguish white pyrites from cobalt and other minerals, which also contain some copper and much arsenic.

Hence then we see, that arsenic is the cause of whiteness in pyrites, and is contained in every pyrites of that color; that copper is the principal cause of the yellow color of pyrites; and that every pyrites which is evidently yellow contains copper; that sulphur and iron produce a pale-yellow color, which is also produced by copper and arsenic; hence some difficulty may arise in distinguishing

guiſhing pyrites by its colors. We may alſo obſerve, that ſulphur and arſenic, without any other ſubſtance, form a yellow compound, as we ſee from the example of orpiment or yellow arſenic. Thus, although the colors of the pyrites enable us to diſtinguiſh its different kinds, and to know their nature at firſt ſight, particularly when we have been accuſtomed to obſerve them; yet we cannot be entirely certain concerning the true nature of theſe minerals, and even of all minerals in general, that is, to know preciſely the kinds and proportions of their component ſubſtances, but by chemical analyſis and decompoſition.

Beſides the above-mentioned matters which compoſe pyrites, it alſo contains a conſiderable quantity of unmetallic earth, that is, an earth which cannot by any proceſs be reduced to metal. Henckel, Cramer, and all thoſe who have examined this matter, mention this earth, and prove its exiſtence.

We ought to obſerve, that this earth is combined with the other principles of the pyrites, and not merely interpoſed betwixt its parts. It muſt therefore be diſtinguiſhed from other earthy and ſtony matters mixed accidentally with pyrites, and which do not make a part of the pyrites, ſince they may be ſeparated by mechanical means, and without decompoſing that mineral: but the earth of which we now treat is intimately united with the other conſtituent parts of the pyrites, is even a conſtituent part of pyrites, and eſſential to the exiſtence of this mineral, and cannot be ſeparated but by a total decompoſition of it.

According to Henckel, this unmetallic earth abounds much in the white pyrites, ſince he found from the analyſes which he made, that the iron, which is the only metal exiſting in theſe pyrites, is only about $\frac{1}{20}$th part of the fixed ſubſtance that remains after the arſenic has been expelled by torrefaction or ſublimation.

A much larger quantity of iron is in the pale-yellow pyrites, according to Henckel. The proportion of iron is generally about twelve pounds to a quintal of pyrites, and ſometimes fifty or ſixty pounds: this is therefore called martial pyrites. It contains about $\frac{1}{4}$ of its weight of ſulphur, and the reſt is unmetallic earth.

The quantity of unmetallic earth contained in the yellow or cupreous pyrites, which are alſo martial, ſince, as we have obſerved, iron is an eſſential part of every pyrites, has not yet been determined. They probably contain ſome of that earth, though perhaps leſs of it than the others.

The nature of this unmetallic earth of pyrites has not been well examined. Henckel thinks that it is an earth diſpoſed already by nature to metallization, but not ſufficiently elaborated to be conſidered as a metallic earth. *See the articles* METALS *and* METALLISATION. This opinion is not improbable; but as alum may be obtained from many pyrites, may we not ſuſpect that this unmetallic earth is of the nature of the baſis of alum or argillaceous earth? *See* ALUM *and* CLAY. Perhaps alſo this earth is different in different kinds of pyrites. The ſubject deſerves to be well examined.

Although pyrites is not ſo valuable as true ores, becauſe in general it contains leſs metal, and but exceedingly little of the precious metals; and becauſe its metallic contents are ſo difficult to be extracted, that, excepting cupreous pyrites, which is called *pyritous copper ore*, it is not worked for the ſake of the

contained metal; yet it is applied to other purpofes, and furnifhes us with many ufeful fubftances; for from it we obtain all our green and blue vitriols, much fulphur, arfenic, alum, and orpiment. *See the principal proceffes by which thefe fubftances are extracted from pyrites, under the article* SMELTING *of* ORES.

As every pyrites contains iron, and moft of them contain alfo fulphur; as the pyrites moft frequently found contains only thefe two fubftances with the unmetallic earth; and as iron and fulphur have a fingular action upon each other, when they are well mixed together and moiftened; hence many kinds of pyrites, particularly thofe which contain only the principles now mentioned, fuftain a fingular alteration, and even a total decompofition, when expofed during a certain time to the combined action of air and water. The moifture gradually penetrates them, divides and attenuates their parts; the acid of the fulphur particularly attacks the martial earth, and alfo the unmetallic earth, its inflammable principle is feparated from it, and is diffipated. While thefe alterations happen, the pyrites changes its nature. The acid of the fulphur which is decompofed forms with the fixed principles of the pyrites, vitriolic, aluminous, and felenitic falts; fo that a pyrites which was once a fhining, compact, very hard mineral, becomes in a certain time a greyifh, faline, powdery mafs, the tafte of which is faline, auftere, and ftiptic.

Laftly, if this mafs be lixiviated with water, cryftals of vitriol, and fometimes of alum, according to the nature of the pyrites employed, may be obtained by evaporation and cryftallization.

This alteration and fpontaneous decompofition of pyrites is called *efflorefcence* and *vitriolifation*; becaufe the pyrites becomes covered with a faline powder; and becaufe vitriol is always formed. This vitriolifation is more or lefs quickly accomplifhed in pyrites according to its nature. It is a kind of fermentation excited by moifture amongft the conftituent parts of thefe minerals; and it is fo violent in thofe which are moft difpofed to it, that is, in the pale-yellow pyrites, which contain chiefly fulphur and iron, that when the quantity of thefe is confiderable, not only a fulphureous vapor and heat may be perceived, but alfo the whole kindles and burns intenfely. The fame phenomena are obfervable, and the fame refults are formed, by mixing well together and moiftening a large quantity of filings of iron and powdered fulphur; which experiment Lemeri has made, to explain the caufes of fubterranean fires and volcanos.

We cannot doubt that, as the earth contains very large maffes of pyrites of this kind, they muft undergo the fame changes when air and moifture penetrate the cavities containing them; and the beft natural philofophers agree, that very probably this furprizing decompofition of pyrites is the caufe of fubterranean fires, of volcanos, and of mineral waters, vitriolic, aluminous, fulphureous, hot and cold.

No other pyrites is fubject to this fpontaneous decompofition, when expofed to humid air, but that which is both martial and fulphureous, that is, the pale yellow pyrites. The arfenical pyrites, or that which contains little or no fulphur, is not changed by expofure to air. This latter kind is harder, heavier, and more compact than the former. The pyrites which is angular and regularly

regularly ſhaped, is chiefly of this kind. Mr. Wallerius, in his Mineralogy, propoſes to diſtinguiſh this kind of pyrites by the name of *marcaſite.* When cut, it may be poliſhed ſo well as to give a luſtre almoſt equal to that of diamonds, but without refracting or decompoſing the light; for it is perfectly opake. It has been employed ſome years paſt in the manufacture of toys, as of buckles, necklaces, &c and is called in commerce *marcaſite.* *See* WATERS (MINERAL), ORES, SMELTING *of* ORES. (*i*)

DLXXII PYROPHORUS *of* HOMBERG. The Pyrophorus is a chemical preparation, which has the ſingular property of kindling ſpontaneouſly when expoſed to air. It was accidentally diſcovered by Mr. Homberg. This chemiſt was endeavouring to extract a limpid and flavorleſs oil from human ordure, which ſhould have the property of fixing mercury (*ſee* EXCREMENTS *of* ANIMALS); and when he had mixed the ſubſtance upon which he was operating with different matters, he was much ſurprized, while he was taking the caput mortuum of one of theſe mixtures out of a retort, four or five days after it had been operated upon, to ſee it kindle and burn ſtrongly as ſoon as it was expoſed to air. He recollected that this was the reſiduum of a mixture of alum and human feces from which he had obtained all that he could by means of a red-heat. He repeated the proceſs, and obtained from it the ſame reſult. When he was well aſſured of it, he publiſhed his diſcovery. Human feces were a long time believed to be eſſential to the operation, till the youngeſt ſon of the great Lemeri found, that honey, ſugar, flour, in a word, any animal or vegetable matter, might be ſubſtituted in place of the human feces; and ſince that time, Mr. Lejay de Suvigny, Doctor of Phyſic, a perſon well verſed in mathematical and phyſical ſciences, has communicated to the Academy a Memoir, relating experiments made on the pyrophorus, in which he generaliſes the proceſs, and gives the true theory of it. He there ſhews, that moſt vitriolic ſalts may be ſubſtituted for the alum; which diſcovery aſſiſted him greatly in explaining the theory of the operation. This Memoir is printed in the third volume of the Collection of Memoirs by correſpondents of the Academy.

(*i*) I do not know any ſufficient reaſon for conſidering the minerals called *pyrites* as a diſtinct claſs of ſubſtances from ores. They have indeed no mark by which they can certainly and conſtantly be diſtinguiſhed from theſe. The hardneſs or property of ſtriking ignited ſparks from ſteel is not common to all the ſubſtances generally called pyrites; for we find ſome of theſe enumerated by mineralogiſts which have not that property. Wallerius even mentions a pyrites which contains no iron, although that metal is thought by Henckel to be eſſential to pyrites. The diſtinction of pyrites from ores has been chiefly introduced by miners; becauſe the greateſt part of the former minerals contain ſo little metal, and ſo much of the mineraliſing ſubſtances, ſulphur, or arſenic, that they are ſeldom ſmelted. Neverthelеſs, ſome kinds of pyrites are found which contain ſo much copper, that they are ſmelted with great profit. Accordingly, ſome later mineralogiſts conſider the cupreous yellow pyrites as an ore of copper, the pale-yellow martial pyrites as an ore of iron, and the white arſenical pyrites as an ore of arſenic. *See* ORES *of* COPPER, IRON, *and of* ARSENIC.

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Although alum is not absolutely necessary for the preparation of the pyrophorus, yet it is one of the vitriolic salts which succeeds best. The following process is very good for this preparation.

Let three parts of alum and one part of sugar be mixed together. This mixture must be dried in an iron shovel over a moderate fire, till it be almost reduced to a blackish powder of coal, during which it must be stirred with an iron spatula. Any large masses must be bruised into powder, and then it must be put in a glass matrass, the mouth of which is rather strait than wide, and seven or eight inches long. This matrass is to be placed in a crucible, or other earthen vessel, large enough to contain the belly of the matrass, with about a space equal to the thickness of a finger all round it. This space is to be filled with sand, so that the matrass shall not touch the earthen vessel: the apparatus is then to be put in a furnace, and the whole to be made red-hot: the fire must be gradually applied, that any oily or fuliginous matter may be expelled. After which, when the matrass is made red-hot, sulphureous vapors exhale: This degree of heat is to be continued till a truly sulphureous flame, which appears at the end of the operation, has continued nearly a quarter of an hour: the fire is then to be extinguished, and the matrass to cool without taking it out of the crucible; and when it ceases to be red-hot, it must be stopped with a cork. Before the matrass is perfectly cold, it must be taken out of the crucible, and the powder it contains must be poured into a very dry glass phial, which must be well closed with a glass stopper. If we would preserve this pyrophorus a long time, the bottle containing it must be opened as seldom as is possible. Sometimes it kindles while it is poured into the glass phial, but it may be then extinguished by closing the phial expeditiously.

When half a dram of this pyrophorus is put on a piece of paper and exposed to air, it quickly kindles, becomes red like burning coals, emits a strongly sulphureous vapor, and burns the paper or other combustible body which supports it.

This preparation has hitherto been used only to entertain curious persons with a sight truly surprizing, of a substance which contains within itself a principle of fire capable of burning spontaneously, and which being more inflammable than any other substance known, kindles without contact of an ignited matter. The phenomena which it exhibits confirm Stahl's theory concerning the composition of sulphur, and give a striking proof of the almost incredible force and activity with which the vitriolic acid, when highly concentrated, but not perfectly combined, unites with the moisture of the air.

In the first place, we cannot doubt that sulphur is formed in the operation of the pyrophorus; for the experiments made by Stahl demonstrate, that the vitriolic acid engaged in any basis quits that basis, and unites with the inflammable principle whenever the circumstances necessary for that union concur; as they all do in this case; and therefore sulphur must be really formed. Besides, although we had not this proof of it, the sulphureous flame seen above the matrass in which the pyrophorus is made, the peculiar smell of sulphur which the pyrophorus when burning exhales, and, lastly, the possibility of obtaining sulphur ready formed, would sufficiently demonstrate this truth. *See* SULPHUR.

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In the second place, probably the whole vitriolic acid of the alum is not employed to form sulphur in the operation of the pyrophorus; not because a sufficient quantity of inflammable principle is not contained in the vegetable or animal matter with which it is mixed; but rather because a sufficient time is not given for that purpose, as we shall presently see.

These preliminary remarks being made, we observe, that probably the portion of vitriolic acid of the alum, which has not had time to form perfect sulphur, being partly disengaged from the earth by the action of fire, and by the presence of the inflammable principle; and being also greatly dephlegmated, since it is in a dry state; is capable of uniting with the moisture of the air as soon as it is exposed to it; and with such activity, that a heat is produced sufficient to kindle the sulphur and a very combustible fuliginous matter which are contained in the pyrophorus. This is the explanation given by Mr. Lejay de Suvigny; and is confirmed by the following observations.

First, the pyrophorus can be made only with substances fit for producing sulphur, or with sulphur itself, as Mr. de Suvigny has shewn.

Secondly, no pyrophorus will be produced, if the mixture be calcined by too long or too violent a fire; because then the whole vitriolic acid can be combined into perfect sulphur, and consequently is engaged, and not in a proper state to attract the moisture of the air; or else if it does not combine into sulphur, it being half disengaged from its basis, is driven off by the violence or long continuance of the fire; and, consequently, after this compleat calcination, no acid remains partly disengaged, as it ought to be, that it might unite with the water with sufficient activity.

Thirdly, when the pyrophorus is very slowly moistened, as when it is kept in a bottle not well closed, it does not kindle, because sufficient heat is not produced by this slow and gradual attraction of water. It is also spoiled and rendered incapable of kindling, when exposed to the open air; because its acid becomes then saturated or nearly saturated with moisture, and cannot therefore unite with that of the air with sufficient activity.

Fourthly, a pyrophorus thus spoiled by exposure to moisture may be restored to its peculiar properties by making it again red-hot in a matrass; since by this calcination its partly disengaged acid is again concentrated, and resumes all its force of combining with water.

Fifthly, the inflammation of the pyrophorus is accelerated by placing it upon paper a little wetted, or by breathing upon it; because the acid then attracts the moisture more hastily, and consequently with more heat.

All these facts clearly prove, that the pyrophorus is inflamed by the extreme heat excited in its parts, from the singular force and activity with which it seizes mosture. But further, as Mr. de Suvigny well remarks, the pyrophorus can only contain the basis of the vitriolic salt employed, the earth of the vegetable or animal substance which furnished the inflammable matter, a coal, some perfect sulphur, and some imperfectly formed sulphur or vitriolic acid, which is but imperfectly engaged either by its basis or by phlogiston. Now of all these substances, the acid only, which is also very concentrated, can attract moisture so forcibly as to produce great heat. To this portion then of vitriolic

vitriolic acid we must attribute the spontaneous inflammation of the pyrophorus. *See* Acid (Vitriolic), Phlogiston, *and* Sulphur.

DLXXIII. PYROTECHNICKS. This Greek name, signifying the *art of fire*, has been given to chemistry, because most chemical operations are made by fire: but it is now confined to the art of composing fire-works. *See* Powder (Gun).

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DLXXIV. QUARTATION. Quartation is an operation by which the quantity of one thing is made equal to a fourth part of the quantity of another thing. Thus when gold allayed with ſilver is to be parted, we are obliged to facilitate the action of the aqua fortis by reducing the quantity of the former of theſe metals to one fourth part of the whole maſs; which is done by ſufficiently encreaſing the quantity of the ſilver, if it be neceſſary. This operation is called quartation, and is preparatory to the parting; and even many authors extend this name to the operation of parting. *See* PARTING.

DLXXV. QUARTZ. Quartz is a hard vitrifiable ſtone, ſomething intermediate betwixt rock-cryſtals and flints, or opake vitrifiable ſtones. Quartz is a ſtone well known by metallurgiſts, mineralogiſts, and miners, as it is frequently and abundantly found with ores, of which it often forms the matrix. It is alſo frequently found where no ores are.

The moſt common quartz is more or leſs of a milky-white color, and conſequently ſemi-tranſparent. Some of them have various colors. This ſtone, which is very hard and very compact, is nevertheleſs cracked throughout its ſubſtance; to which alſo the rock-cryſtal is very liable, but much leſs ſo than quartz. The fragments of quartz are always angular, and its internal ſurface has but little gloſs. Quartz is a little waved, and has a greaſy appearance. It is found not only of various colors but alſo of various forms. It is frequently found cryſtallized in caverns and ſlits of rocks. Its cryſtallization is the ſame as that of rock-cryſtal. Quartz may be employed in vitrification, as all other vitrifiable ſtones are. *See* EARTHS (VITRIFIABLE) *for the nature and properties of quartz; and alſo the mineralogy of Wallerius, and the Dictionnaire d'Hiſtoire Naturelle de M. Bomare, for the different kinds of it.*

(*k*) Quartz is a ſtone of the kind called by authors *ſiliceous* or *vitrifiable*. Some of theſe ſtones conſiſt of impalpable particles, others have a granulated texture, and laſtly ſome have a ſparry or laminated texture. When pure, they are white and opake, or

DLXXVI. QUICKLIME. This name is given to all the earths and ſtones which have acquired, by expoſure to a certain heat, the following properties. [*Concerning the properties of theſe earths before calcination, ſee the article* EARTH (CALCAREOUS)].

Theſe ſtones by calcination loſe half of their former weight, and much of their hardneſs. This alteration ſhews that the calcareous ſtones, before calcination, are not a pure earth, but a compound of a fixed earthy matter and of ſome volatile ſubſtance, of which they may be deprived by fire.

After the calcination has been completed, and the ſtones are become cold, if water be applied to them, it penetrates them with conſiderable heat and violence, divides and ſeparates their parts, and reduces them to a very fine paſte, if the quantity of water added has not been too great. The paſte of quicklime thus ſlaked ſtrongly retains the water, and when mixed with ſand or with pounded baked clay, it becomes very hard in a certain time. This mixture is called *mortar*.

The water employed to ſlake the quicklime diſſolves a part of it, and is called *lime-water*. When this water is expoſed to evaporation, a ſemi-cryſtalline pellicle is formed on its ſurface, which is the diſſolved quicklime: this pellicle ſoon falls to the bottom, and another is formed on the ſurface, till almoſt all the earthy matter once diſſolved be ſeparated from the water. Lime-water has a ſharp, urinous taſte, which the calcareous earth had not before calcination.

The ſlaked lime by another calcination is reduced to the ſtate of quicklime, as it was before.

Quicklime combines with the moiſture of the air which it ſeems capable of attracting. By the moiſture thus attracted, the weight of the quicklime is doubled, its bulk is alſo encreaſed, its parts are very much divided, and it is reduced to an exceeding fine powder. In this ſtate it is called *lime ſlaked in the air*.

Lime ſlaked in the air may be reduced, by another calcination, to its former ſtate of quicklime, in the ſame manner as lime ſlaked by water.

Quicklime is capable of uniting with certain ſubſtances, (as, for inſtance, with ſulphur, with which it forms an *earthy liver of ſulphur*) to which the uncalcined calcareous earth could not unite ſo intimately.

they are colorleſs and tranſparent. When mixed with calxes of iron or of copper, they are black or red. This ſtone does not decay in the air, as ſome other ſiliceous ſtones do. According to Cronſtedt, it always forms hexagonal priſms, pointed at one or both ends, when there has been no interruption to its cryſtallization; and this cryſtallized quartz is rock-cryſtal, which, like the uncryſtallized quartz, is colorleſs or colored, tranſparent or opake. *See* CRYSTAL.

Wallerius ſays, that every quartz is fuſible by fire: but probably the quartz colored by metallic calxes are only fuſible; for Mr. D'Arcet found that the tranſparent and ſemi-tranſparent quartz, and alſo the opake white quartz, were rendered friable, but were not fuſed by a very violent and long continued fire; and that by the ſame fire the form and tranſparency of rock-cryſtals were not altered. *Memoir ſur l'Action d'un Feu Violent, Egal, & Continué, &c. Mem. de l'Acad. des Sc.* 1766.

Becher and Hiærne ſay, that from quartz a ſmall quantity of alkali may be obtained by diſtillation or by frequent extinction of the heated ſtone in water. A ſimilar alkaline matter is ſaid to be obtainable by diſtillation from flints.

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An important queſtion deſerves to be examined, concerning the nature of the volatile ſubſtance of which calcareous ſtones are deprived by fire, and whether the ſeparation of this volatile matter is the cauſe of the phenomena produced by quicklime.

As the properties of quicklime reſemble much thoſe of ſaline ſubſtances, and as even a kind of ſaline matter is obtained from it, moſt chemiſts have believed, that all calcareous ſtones contain more or leſs of ſome ſalt; which being mixed with an earthy matter, cannot ſhew its properties till it has been partly unfolded and diſengaged by the action of fire. Their opinion is grounded on ſome ſaline matter obtained from calcareous ſtones by diſtillation with a violent fire, or from quicklime after its calcination.

Van Helmont, and after him Daniel Ludovicus, pretend to have made an experiment from which they have inferred a peculiar opinion. Theſe chemiſts, having expoſed lime-ſtone to a violent fire in a retort, obtained only a pure water; and they affirm, that the remaining ſtone was not by this operation converted into quicklime. This experiment, together with ſome marks which may be perceived of inflammable matter being contained in lime-ſtone, has induced them to believe, that this inflammable matter is ſo intimately united with the ſaline part of the lime-ſtone, that this cannot exert its properties; and that this matter being, like coals, incapable of combuſtion in cloſe veſſels, it cannot diſengage the ſaline part, that is, quicklime cannot be made, but by calcination in open fire.

Mr. Macquer has repeated this experiment, as may be ſeen in his Memoir upon Quicklime, (Memoirs of the Academy of Sciences, 1747) and found it to be only true in part.

This chemiſt, having expoſed lime-ſtones in a retort to a violent fire continued during ſix hours, obtained a purely aqueous liquor, which ſhewed no ſaline property, and obſerved that the remaining ſtone, though not entirely converted into quicklime, had nevertheleſs acquired all the properties of quicklime in a great degree. The calcination was therefore found to ſucceed in cloſe veſſels without the combuſtion of any inflammable matter contained in the ſtone. *See* CALCINATION.

We are certain therefore, that the experiment of Van Helmont and of Ludovicus proves nothing in favor of their opinion.

Stahl believes, with more probability, that all the properties of quicklime proceed merely from ſuch a diviſion and disjunction of the integrant parts of the calcinable earth, by means of the calcination, that they are rendered capable of uniting with the particles of water. He believes that this union is already begun in lime-ſtone; that the fire, during the calcination, does only ſeparate the principles of this compound body, that is, expels the watery part, which being volatile, is incapable of reſiſting the action of fire, and ſeparates it from the earthy principle, and does not deprive the latter principle of its diſpoſition to unite with the former, but rather encreaſes this diſpoſition by attenuating the earthy matter. This theory explains in a ſatisfactory manner all the phenomena of quicklime.

All the properties of calcareous ſtones by which they differ from vitreſcible ſtones, that is to ſay, their inferior degrees of hardneſs and of weight, and the

loſs of matter which they ſuſtain by violent fire [*See* EARTH (CALCAREOUS), *and* EARTH (VITRIFIABLE)] ſhew, that they contain a principle leſs hard, leſs weighty, and leſs fixed than pure earth: but theſe are preciſely the eſſential properties which conſtitute the difference betwixt earth and water.

In fact, the experiments of Van Helmont, Ludovicus, and of Mr. Macquer ſhew, that water is the principle ſeparated from lime-ſtone during its calcination.

The difficulty with which fire expels all the watery part of lime-ſtone ſhews, that in this ſtone there is at leaſt ſome degree of the union of compoſition, and a true adheſion betwixt the integrant parts of water and thoſe of earth, and alſo gives an inſtance of the great degree of fire which water is capable of ſuſtaining when it is retained by means of an union contracted with a fixed matter. The degree of heat ſuſtained by water on this occaſion muſt neceſſarily enable the water to ſeparate more and more the integrant parts of the earthy matter, and to break their aggregation (in the Digeſtor of Papin), and to give it conſequently a greater diſpoſition to re-unite with water.

This being eſtabliſhed, if we add to quicklime the watery principle which the violence of the fire has expelled, the earthy particles having acquired by calcination a ſtrong diſpoſition to unite with water, theſe two ſubſtances will accordingly unite together with great activity; and as the primary molecules of the two uniting ſubſtances are very hard, the friction occaſioned by their motion during their union muſt produce a conſiderable heat.

This new union contracted by the parts of quicklime with water is much more perfect and more intimate than the union of the conſtituent parts of the lime-ſtone before calcination. As water and earth are the two elements of ſaline ſubſtances (*ſee* SALT), a new, at leaſt, a beginning combination muſt be formed by the extinction of quicklime. In conſequence of this combination, a taſte is given to lime-water, and *cream of lime* is produced, which is ſoluble in water, and ſeparable from thence like a true ſalt, and which muſt be conſidered as a ſaline matter, begun at leaſt, and overcharged with the earthy principle.

It appears certain that the cream of lime is not produced by any ſalts originally mixed with the lime-ſtone, unfolded by the action of fire, and thereby reſtored to their properties and ſolubility in water; for it is not credible that at leaſt the greateſt part of the ſaline matter, which may have been originally mixed with the calcareous earth of lime-ſtones, ſhould not have been already waſhed away by the water to which theſe ſtones have been often expoſed ſince their formation. Beſides, ſuppoſing even that ſome of that ſaline matter ſhould have remained, certainly it would be all waſhed out by one calcination of lime ſtone, and extinction in water: but we know that quicklime once extinguiſhed, and boiled in any quantity of water, may, by another calcination, be reſtored to the ſtate of quicklime, and to the property of ſolubility in water, and of producing cream of lime as much as before. This phenomenon affords an additional proof, as well as an explanation of the theory of Stahl.

Further, the addition of any ſaline ſubſtances to lime-ſtones, which when calcined yield but a weak quicklime, not only does not render the quicklime more ſtrong and active, but, on the contrary, conſiderably injures its quality.

Theſe

Theſe facts have been advanced by Mr. Macquer, in his Memoir upon Quicklime, and they ſhow that the properties of calcareous ſtones acquired by calcination are not occaſioned by the preſence of any ſaline matter.

The firm adheſion of the water to ſlaked quicklime deſerves attention, and is ſo conſiderable, that the water cannot be entirely ſeparated but by a fire as violent as is required for the firſt calcination of lime-ſtone.

Mr. Duhamel has made a deciſive experiment to ſhew the ſtrength of this adheſion.

Having weighed an ounce of ſlaked quicklime, which had previouſly undergone ſeveral ſtrong calcinations to deprive it of all its water; and obſerving that each ounce of this quicklime, notwithſtanding all theſe calcinations, retained more than three gros and thirty-eight grains of water, he expoſed it again to a very violent fire in a melting furnace, and found that notwithſtanding this further calcination, his ounce of quicklime ſtill retained twenty grains of moiſture. *(Mem. of the Acad. of Sc. 1747).*

This retention of the water united to quicklime during its extinction may be naturally deduced from the adheſion contracted between earth and water; which two ſubſtances really form a new compound conſiſting of two principles, one of which is fixed, and the other is volatile, and in which the volatile part is retained by the fixed part with a ſtrength proportionable to the perfection of the combination of theſe two ſubſtances. Hence we may explain the cauſe of the difficulty of drying ſlaked lime, and of the ſeveral phenomena before related which happened upon expoſure of quicklime to air, and alſo of ſeveral other properties hereafter to be mentioned, all which ſhew the ſaline quality of this ſubſtance. It unites to all acids with the ſame phenomena, as it does before calcination: and the neutral ſalts with earthy baſes, which are formed by the calcareous earth in theſe two ſtates, are very ſimilar to each other. [*See* SALTS (NEUTRAL) *with* EARTHY BASES].

Neverthleſs it ſeems as if the acid of all thoſe ſalts, the baſis of which is quicklime, adheres more ſtrongly than the acid of ſalts, the baſis of which is uncalcined calcareous earth.

Lime-water, which keeps diſſolved the moſt attenuated and moſt ſaline portion of the quicklime, as we have already ſhewn, decompoſes all ſalts with metallic baſes.

Laſtly, quicklime produces alterations upon fixed and volatile alkalis, which cannot be effected by uncalcined calcareous earths.

Fixed alkalis, treated with quicklime, become much more difficult to be dried, more deliqueſcent, more cauſtic, and much more powerfully ſolvent. The ſame alterations are produced by means of quicklime upon volatile alkali, which is thereby rendered much more penetrating, and ſo ſtrongly deliqueſcent that it cannot be then obtained in a concrete ſtate.

Theſe changes are probably produced by the quicklime depriving the alkalis of ſome inflammable matter; and as probably the remaining inflammable matter is a conſtituent part of theſe alkalis, we need not be ſurpriſed that their properties are changed, and that even a decompoſition of their parts ſhould happen upon the quicklime depriving them of this inflammable matter, if the action of the quicklime be ſufficiently applied. And accordingly it happens that by

a continued treatment of fixed and volatile alkalis with quicklime, they may be at laſt entirely deſtroyed.

As ſimple calcareous earths do not produce the ſame effects upon alkalis, it follows that quicklime has a more powerful action than thoſe earths upon inflammable matters; and accordingly we find that quicklime unites more intimately than calcareous earths with oils and with ſulphur, forming with this latter ſubſtance a kind of earthy liver of ſulphur, which is ſoluble in water to a certain degree.

This action of quicklime upon alkalis and upon inflammable matters is advantageouſly applied to give activity to the former, and to make them more capable of uniting with oils. Accordingly, the alkali employed in the compoſition of ſoap ought to be always ſharpened by quicklime. *See* SOAP, *and* LEY *of* SOAP-BOILERS.

Fixed alkali ſharpened by quicklime, and reduced to a ſolid conſiſtence by drying, is much more cauſtic than ordinary alkali, and is employed as a cautery. *See* CAUSTIC (COMMON).

The moſt general uſe of quicklime is for building. The property which ſlaked lime has, when mixed with ſand, of forming a *mortar* or cement capable of hardening and acquiring a ſtoney conſiſtence, renders it uſeful for the joining of ſtones of buildings, pavements, &c. This mortar has alſo the advantage of being impenetrable by water, when it has once become ſolid. *See* MORTAR.

Quicklime has medicinal virtues. As an abſorbent earth, it is anti-acid, and is capable of abſorbing any acids which are produced in the ſtomach by a debility of that organ, in the diſeaſes proceeding from a ſpontaneous acid, ſo well deſcribed by Boerhaave. It is ſo much better adapted to thoſe diſeaſes which are always cauſed by inactivity, and by the weakneſs and laxity of the fibres, as it has a tonic quality, which ſimple abſorbent earths have not. *See* EARTHS (ABSORBENT).

As quicklime is alſo drying, and ſomewhat cauſtic, and conſequently cicatriſing, it may contribute to the cure of certain ulcers, eſpecially of the ſoft parts: accordingly ſeveral able phyſicians have preſcribed it ſucceſsfully even for internal ſuppurations, and for the phthiſis of the lungs.

Laſtly, the property which quicklime has of attenuating viſcid matters, and of decompoſing ammoniacal ſalts, has been advantageouſly applied in theſe later times to diſſolve ſtones in the kidneys and bladder. An Engliſh phyſician has made on this ſubject ſome experiments capable of giving hopes of ſucceſs; and M. Roux, Doctor-Regent of the Faculty of Medicine at Paris, who has alſo given other proofs of his chemical abilities, has added conſiderably to theſe experiments; a relation of which, with his own additions, he has publiſhed in French. *(l)*

(l) The experiments made by Dr. Black on quicklime, and related in the Eſſays phyſical and literary publiſhed at Edinburgh, have enabled that excellent chemiſt to form a new and ſatisfactory theory of the changes produced upon calcareous earths by means of calcination, and of thoſe produced upon alkalis by means of quicklime. Theſe we have already mentioned under the articles AIR (FIXABLE), ALKALIS (FIXED *and* VOLATILE), and ſome others. We ſhall nevertheleſs place under one view the principal facts and doctrines concerning quicklime, and for more minute explanations and proofs, we refer to the above-mentioned articles, but eſpecially to the Eſſay itſelf abovequoted.

The

The best method of administering quicklime, especially for internal use,

The class of earths and stones called by naturalists *calcareous*, or chalks and marbles, or those which by calcination are convertible into quicklime, are found by experiments to consist of the following component parts. 1. Of *quicklime*, or pure and uncombined calcareous earth. The quantity of this in a piece of chalk was found by Dr. Black to be equal to $\frac{64}{120}$ of the whole, the remaining $\frac{56}{120}$ parts having been extricated by calcination. 2. Of *fixable air*, which when extricated is found to be permanently elastic, and uninflammable. Concerning its properties, *see* AIR (FIXABLE). The quantity of this air extricated from a piece of chalk, during its solution in an acid, was found by an experiment of Dr Black to be equal to $\frac{2}{5}$ of the whole mass; and the quantity of air extricated from a piece of marble was found by Mr. Cavendish to be $\frac{407}{1000}$ of the whole mass. As the results of the experiments made by these two gentlemen so nearly concur, we have reason to believe that mild calcareous earth is always united and saturated with a determinate quantity of fixable air. 3 Of *water*. A certain quantity of water is always extricated from calcareous stones during their calcination, and may be collected by distillation of these stones with a retort and receiver. The quantity of water obtained from the distillation of osteocolla, which is a calcareous earth, by Mr. Margraaf, was found to be equal to $\frac{1}{32}$ of the whole mass. Dr. Black found that chalk lost by calcination $\frac{52}{120}$ of its weight. If we deduct from that loss, the $\frac{2}{5}$ which he found by an experiment abovementioned was the quantity of fixable air contained in chalk, the remainder $\frac{4}{120}$ or $\frac{1}{30}$ will be the quantity of water, which is nearly equal to the quantity obtained from osteocolla. Hence also we have reason to believe that a certain determinate quantity of water is united with and saturates the calcareous earth, when mild, or united with fixable air. But when this earth is separated from its fixable air, it becomes then capable of uniting with a much larger quantity of water, which is also probably determinate, as we shall find when we consider the properties of quicklime.

These are the only component parts of the purer chalks, marbles, calcareous spars, and stalactites; but many of the stones and earths which are usually calcined for making quicklime, as many of the common lime-stones and marles, contain, besides the earth properly called calcareous, various other substances intermixed, as sand, or vitrifiable earth, clay, and metallic calxes. Some of these, as sand and metallic calxes, if not in too large quantities, are useful ingredients in the composition of mortar. But we must in this article be understood to mean calcareous earth unmixed with any other matters. The quantity of calcareous earth in any lime-stone may be discovered by observing how much of that stone is soluble in marine or nitrous acids, and by adding to the solution of the calcareous earth some caustic volatile alkali, by means of which, if any other earth, as earth of alum, metallic earths, &c. have been dissolved by the acid, these will be precipitated, and the calcareous earth alone will remain dissolved. By comparing the weight of the stone originally employed with the weight of the undissolved and precipitated parts, the quantity of calcareous earth in that stone may be found: or this quantity may be precipitated from the acid in which it is dissolved, by adding to the above solution of calcareous earth some mild fixed or volatile alkali, till no further precipitation is occasioned.

Native calcareous earths and stones may be decomposed, or resolved into the above-mentioned component parts, by fire or by acids.

When they are exposed to fire, the water and the fixable air are volatilised, and separated from the earthy part, which remains singly, and is then quicklime.

When an acid is applied to native calcareous earths, their fixable air is disengaged, recovers its elasticity, and is dissipated, while the acid remains united with the earth and the water, forming a salt with basis of calcareous earth. *See* SALTS. The earth or quicklime may be separated from the acid by means of a fixed alkali, which having a greater disposition to unite with the acid, precipitates the earth. If the alkali employed be caustic, or deprived of fixable air, the earth precipitated will be also caustic, or quicklime. But if the alkali

kali

is lime-water, becauſe this water has all the medicinal properties of quicklime,

kali employed be mild, that is, combined with fixable air, this air will unite with the earth; and thus the quicklime will be rendered mild, or reſtored to its original ſtate of native calcareous earth, combined with air.

Quicklime has the following properties. 1. It is entirely ſoluble in water, with which it unites ſo rapidly, as to occaſion conſiderable heat. When expoſed to air, it imbibes moiſture from thence. When united with as much water as is ſufficient to make it a fluid paſte, it is called *ſlaked lime*. Water ſaturated with quicklime is called *lime-water*. According to Brandt, lime-water contains about one part of quicklime to ſeven or eight hundred parts of water. Slaked lime, or lime-water, being expoſed to the atmoſphere, attract from thence particles of fixable air which float in it, by which means the quicklime is rendered mild, unſoluble in water, and therefore appears on the ſurface of the lime-water or of the ſlaked lime where this combination happens, in the ſtate of mild or combined calcareous earth, convertible by a ſecond calcination into quicklime, and is called *cream of lime*.

If the earth diſſolved in lime-water be precipitated from thence by any ſubſtance containing fixable air, as by mild alkalis, or magneſia, it will unite with this air, become mild, and reſume its former weight and properties which it poſſeſſed before calcination. But if it be precipitated from the water by means of ſome ſubſtance which does not contain fixable air, but which is more ſtrongly diſpoſed than the earth to unite with the water, for inſtance, ſpirit of wine, the earth thus precipitated will be in the ſtate of quicklime, that is, cauſtic, and ſoluble in water.

2. Quicklime unites with acids without efferveſcence, which is nothing elſe than an extrication of the fixable air, of which quicklime has been already deprived. It nevertheleſs ſaturates as much acid as it would have done if it had not been calcined.

3. Quicklime is more powerfully diſpoſed to unite with fixable air than fixed or volatile alkalis, or magneſia. Hence, when treated with theſe ſubſtances, it takes from them their fixable air, and is itſelf rendered mild, and reſtored to its original weight and properties. Thus two drams of chalk, having been by calcination reduced to one dram and eight grains of quicklime, were thrown into a filtrated ſolution of an ounce of mild fixed alkali in two ounces of water, and digeſted during ſome time; by which the calcareous earth became mild, and weighed one dram and fifty-eight grains. By means of magneſia, the calcareous earth may be precipitated from lime-water, and this earth is found to be mild, and to have deprived the magneſia of its fixable air. By depriving alkalis of their fixable air, quicklime renders them more cauſtic and ſolvent, for the ſame reaſon that itſelf is by this privation of air rendered more cauſtic and powerfully ſolvent. This increaſe of cauſticity and diſſolving power is conſiſtent with a general rule, namely, that the more ſimple or leſs compounded any body is, that is, the leſs its general tendency to union is ſatisfied, the more diſpoſed it is to unite with or diſſolve other ſubſtances. *See* AIR (FIXABLE), ALKALIS.

4. Quicklime has a diſpoſition to unite with ſulphur, with which it forms a hepar of ſulphur, ſimilar to that made by ſulphur united with an alkali, and, like this, ſoluble in water. It is alſo diſpoſed to unite with oils and with animal and vegetable matters, by which means it poſſeſſes a cauſtic and corroſive property.

5. Quicklime mixed with ſand forms a maſs which hardens, and is uſed as a cement or mortar. The hardening ſeems to be occaſioned by a cryſtallization of the calcareous earth when the ſuperfluous water is exhaled, and is ſimilar to the hardening of calcined gypſum or plaſter of Paris, when mixed haſtily with a ſufficient quantity of water to effect the cryſtallization of its minute particles. The uſe of the ſand added to quicklime in making mortar is to prevent thoſe cracks which would be formed by the drying of the calcareous earth, and by which its coheſion would be greatly diminiſhed. This effect the ſand produces, by dimi-

niſhing

and because the parts of the quicklime dissolved in it are exceedingly fine, and consequently perfectly distributed. *See* WATER (LIME).

nishing the proportion which the contraction of dimensions, occasioned by drying, bears to the dimensions of the whole mass, which is to be thus exposed to contraction and drying; the sand being itself incapable of suffering any contraction.

R.

DLXXVII. RAIN. *See* WATER.

DLXXVIII. REALGAR, *or* REALGAL. These names have been given to compositions of sulphur and arsenic. These two substances are capable of uniting together, especially when they are reduced to vapors, and sublimed together. The whiteness of crystalline arsenic is always altered by union with sulphur; and the new compound becomes yellow, inclining more or less to an orange, or even to a red color, according to the quantity of sulphur united with the arsenic. When the sulphur is only a tenth part of the whole mixture, the sublimate is yellow. It is then called *yellow realgar*, or *yellow arsenic*, and in commerce *orpiment*.

When the sulphur is a fifth part of the combination, the sublimate is red. It is then called *red realgar*, *sandarach*, *red arsenic*, &c. To few substances have so many names been given as to arsenic and its compounds, as may be seen in several authors of mineralogy, and particularly in Henckel's Pyritologia.

As sulphur fixes arsenic a little, the red realgar may be melted with a gentle heat; and when it has become solid, it is transparent, and then is called *ruby of sulphur*, or *arsenical ruby*.

These combinations of arsenic and sulphur are not generally made in laboratories, because they do not succeed well, as Henckel remarks, when pure arsenic and pure sulphur are sublimed together. They are prepared in countries abounding in ores, which are smelted by mixing together some that contain arsenic, as the *white pyrites*, with others that contain sulphur, like the *sulphureous pyrites*, or *sulphureous scorias*, the quantity of each of which is proportioned as experience taught.

These artificial combinations of sulphur and arsenic ought to be distinguished from those which nature offers to us ready made, as orpiment. They have been very improperly confounded by several authors. Both the natural and artificial compounds are poisons, although Hoffman says that the natural orpiment

piment is not poisonous. The yellow and red artificial arsenics are probably more pernicious. The principal use of these substances is for painting.

When arsenic and sulphur are thus well combined together by sublimation, they cannot be separated without some intermediate substance, because they are volatile: but this separation may be effected by means of fixed alkali or mercury. *See* ARSENIC.

DLXXIX. RECEIVER. Receivers are chemical vessels, which are adapted to the necks or beaks of retorts, alembics, and other distillatory vessels, to collect, receive, and contain the products of distillations.

Receivers ought to be made of glass, not only because this matter resists the action of the strongest and most corrosive substances, but also because being transparent it allows the operator to see through it, and to judge by the frequency of the drops, if the distillation be too fast or too slow, and also if the quantity and nature of the substances which come over be such as is required.

Almost all receivers are kinds of bottles of different sizes, of a spherical form, the necks of which are cut short, and each of which is pierced with a small hole in its lateral or upper part, to give vent to the air or vapors which are too expansive. Receivers of this form are called *balloons*. *See* BALLOON.

Some receivers are matrasses with long necks. These are generally adapted to the beaks of glass alembics. This long neck serves to keep the belly of the receiver, where the liquor is collected, at a proper distance from the fire.

Receivers have different forms for particular operations. Such are those which have two or three beaks, either to be adapted to other receivers, or to admit at the same time the necks of several distillatory vessels, when the intention of the operator is that the vapors of different substances should meet in the same receiver. Such also are *receivers for essential oils*, which are very convenient for the distillation of these oils. To obtain the essential oil of aromatic plants, these plants must be distilled with water. The plant and the water are to be put together into a cucurbit, and the water, which is to receive a boiling heat, rises in distillation, carrying with it the essential oil, which also has the property of rising with this degree of heat. *See* OILS.

As a large quantity of water must be employed, that the plant may always be kept immersed in the alembic, and consequently as a good deal of it rises in proportion to the oil, any receiver of ordinary size would be soon filled with water, with a little oil floating upon its surface; and would require to be frequently changed, which would be very troublesome, and would occasion a loss of part of the oil.

These inconveniencies are avoided by using receivers contrived purposely for such distillations. They are so made, that they are never full, but that the water runs out, and leaves the oil behind. They are a kind of glass cucurbits, which contract as they rise higher; so that their neck or upper opening is but nearly of a convenient size to receive the beak of the *worm*. These receivers have another opening about the middle of the swelling or belly; and to this opening is joined a glass tube, which bends and rises vertically along the outer part of the receiver, so as to be within two inches and a half as high as the upper opening. At this height the tube bends again towards the side opposite

to the body of the receiver, to pour into another veſſel the liquor which riſes there. It forms the figure of S.

When this receiver is to be uſed, it is to be placed vertically under the beak of the worm. During the diſtillation, the liquor riſes to an equal height in the body of the receiver and in the crooked tube: when therefore the height of the liquor in the receiver becomes greater than the height of the tube, it muſt begin to flow from the mouth of this tube into another veſſel placed on purpoſe to receive it: but as eſſential oils are either lighter or heavier than water, and as they are therefore always collected either above or under the water, and as the liquor which diſcharges itſelf through the tube is taken from the middle part of the receiver, therefore nothing but water can be evacuated at the mouth of the pipe, while the oil always remains in the receiver. Thus, with ſuch a receiver, we may diſtill without the trouble of changing the veſſels; which is certainly very advantageous.

DLXXX. RECTIFICATION. By rectification is meant the exact purification of certain ſubſtances, by means of *diſtillation* or of *ſublimation.*

This operation is neceſſary to diſengage many chemical products or agents from a mixture of extraneous matters which deſtroy their purity. Thus, for inſtance, vitriolic acid, when firſt obtained from *vitriol* or from *ſulphur*, is always charged with a conſiderable quantity either of inflammable matter, which renders it black and ſulphureous; or of ſuperabundant water, which weakens it. It is ſeparated from both theſe matters by a ſecond diſtillation, in which they being more volatile than the acid, are carried off; which ſecond diſtillation is called *concentration* or *rectification of vitriolic acid. See* CONCENTRATION *of* VITRIOLIC ACID.

Alſo when animal and vegetable matters are decompoſed by diſtillation, all the portion of oil that is not volatile contained in theſe ſubſtances does not riſe but with a degree of fire ſo ſtrong as to burn a part of them, and to raiſe along with them a conſiderable portion of ſaline ſubſtances, which, being mixed with the oily part, conſiderably alter its purity. To purify theſe oils, which, from their burnt ſmell, are called *empyreumatic*, new diſtillations muſt be applied, in which, by means of a leſs heat, the moſt volatile and pureſt part of theſe oils is ſeparated from the moſt empyreumatic and ſaline parts, which remain at the bottom of the retort: this is called the *rectification of empyreumatic oils. See* OIL (RECTIFIED ANIMAL) *or of* DIPPEL.

The ardent ſpirits obtained by a firſt diſtillation of liquors which have undergone the ſpirituous fermentation, are overcharged with a large quantity of phlegm and light oil, which riſe along with them in this firſt diſtillation. The product of this diſtillation is called *aqua vitæ.* It is an ardent ſpirit very far from the degree of dephlegmation and purity which good ſpirit of wine ought to have to render it fit for chemical operations, and for ſeveral compounds commonly uſed, ſuch as perfumed waters and *liqueurs* for the table. This ſpirit of wine is to be purified, or rather the aqua vitæ is to be changed into ſpirit of wine by new diſtillations, ſlowly conducted with a gentle fire and water-bath, by means of which the moſt volatile part that always riſes firſt with the leaſt heat, and which is the true ſpirit of wine, is ſeparated from the leſs volatile part that remains in the alembic, and which contains the phlegm and

oil

oil of wine, by which the ſpirit of wine was rendered impure. The firſt liquor of theſe ſecond diſtillations or rectifications is called *rectified ſpirit of wine. For its properties ſee* Spirit (Ardent).

When only a ſmall quantity of ſpirit of wine is to be rectified, the operation is difficult, eſpecially when we would have it perfectly rectified. The cauſe of this difficulty proceeds from the very ſmall quantity of the firſt liquor obtained in this rectification. Several chemiſts, to obtain a larger quantity of the firſt ſpirit, propoſe to mix with the ſpirit of wine ſome intermediate ſubſtances to abſorb and retain its phlegm and oil, ſuch as dried and calcined ſalts, very dry chalk, &c. Kunckel propoſes to ſeparate more effectually the oil, by adding to the ſpirit a large quantity of water, and by diſtilling this diluted ſpirit with a very gentle heat. This method is indeed very capable of facilitating the ſeparation of the oil of wine from the ſpirit of wine; becauſe this oil certainly adheres to the ſpirit, which is the chief obſtacle to its ſeparation; and becauſe the ſpirit of wine has greater affinity with water than with oil; ſo that when it is diluted with much water, it quits the oil to unite with the water. This expedient of Kunckel is therefore very good to facilitate the ſeparation of ſpirit of wine from the oil which renders it impure; but, on the other hand, when it is practiſed, we are afterwards obliged to deprive the ſpirit of wine of the water with which it was diluted.

All this trouble and inconvenience may be avoided by rectifying at once a large quantity of aqua vitæ. Nothing more is required to obtain at once a conſiderable quantity of pure ſpirit of wine, than to ſet aſide the twelve or fifteen pints firſt drawn over from a large quantity, ſuppoſe from three hundred pints of aqua vitæ, diſtilled with a very gentle fire in a large alembic. As the moſt ſpirituous, leaſt aqueous, and leaſt oily part of it always riſes firſt, theſe twelve or fifteen pints are perfectly rectified ſpirit of wine, eſpecially when the heat has been well conducted. By thus keeping apart portions of the ſpirit obtained at different times, we may have ſpirit of wine of the ſeveral degrees of ſtrength and purity. The weaker ſpirit may, by another diſtillation, be again rectified. Laſtly, the ſpirit of moderate ſtrength may be preſerved, as it is fit for many uſes. This method is followed by Mr. Beaumé in the rectification of ſpirit of wine, and is certainly the moſt convenient and the beſt.

The volatile ſalts obtained in the decompoſition of certain oily ſubſtances, as volatile alkalis, from decompoſed animal matters, are always very impure, and ſpoiled by much fetid empyreumatic oil, which riſes along with them. They are purified and diſengaged by ſubjecting them to new diſtillations or ſublimations with a well conducted heat. The ſame obſervation is applicable to butter of antimony, artificial cinnabar, phoſphorus, and of many other chemical products, which are always impure when obtained by a firſt operation, and muſt therefore be purified by a ſecond diſtillation or ſublimation. All theſe ſecond operations, intended merely to purify matters, are called rectifications. They are not generally attended with much difficulty. We ſhall not therefore enter into the details of them; but we ſhall obſerve only, that all rectifications are founded upon the ſame principle. They all conſiſt in ſeparating ſubſtances more volatile from ſubſtances leſs volatile; and the general method of effecting this is to apply only the degree of heat which is neceſſary to cauſe this ſeparation. *See* Distillation *and* Sublimation.

CLXXXII.

DLXXXI. RED. (m)

DLXXXII. REDUCTION *or* REVIVIFICATION. This word, in its most extensive sense, is applicable to all operations by which any substance is restored to its natural state, or which is considered as such; but custom confines it to operations by which metals are restored to their metallic state after they have been deprived of this state, either by the loss of their phlogiston, as metallic calxes, or by the union of some heterogeneous matters which disguise them, as *fulminating gold*, *luna cornea*, *cinnabar*, and other compounds of the same kind. These *reductions* are also called *revivifications*. We shall treat of both these kinds of reduction.

The reduction of metallic calxes regards only imperfect metals; because these alone are susceptible of losing their metallic properties by the loss of phlogiston. They may be deprived of this principle by the action of air or of water, which changes them to *rust*; or by the action of acids, particularly of the nitrous and vitriolic; or, lastly, by ordinary calcination, that is, by the combustion of their phlogiston in an open fire.

Metals deprived of their phlogiston by any of these causes have not their peculiar color, lustre, ductility, nor even consistence and gravity. They have the appearance of earths, the parts of which are unconnected, unless they have sustained a fire violent enough to fuse them; and then they become brittle vitrified matters.

But these metallic earths, calxes, or glasses, are capable of being again combined with the inflammable principle, and of recovering all the metallic properties. For this purpose their calcination or dephlogistication must not have been too compleat, and the phlogiston must be applied in a state favorable for combination. These calxes, particularly those of metals which cannot be radically calcined, as lead, bismuth, iron, and copper, may recover their phlogiston, and may be reduced even without fire or fusion, merely by the contact of phlogistic vapors; for instance, by the vapor of liver of sulphur; or they may be reduced in the humid way; that is, when they are precipitated by some substance capable of applying phlogiston to them.

But we must observe, that metals reduced by either of these methods are only superficially so, when the metallic masses are considerably large; and that when the metals thus reduced consist of fine molecules, these molecules, although well reduced and provided with all their metallic properties, remain always disjoined and separated from each other; either because they are not small enough, or because they have not time to unite and agglutinate together, as they have when they are combined by nature; for metals are certainly formed naturally by these methods: but the operations of our laboratories are very different from those of nature. Accordingly, in practical chemistry a much more expeditious method for making these reductions is employed; which is fusion.

The reduction of metallic calxes by fusion is generally a quick and easy operation. It, however, requires certain attentions and management; which

(m) RED. Concerning the substances which give a red color to stuffs, glass, enamels, &c. *see the articles* FLOWERS, FRUITS, COCHINEAL, MADDER, KERMES, LAC, DYING, MANGANESE, POWDER *of* CASSIUS, ENAMEL.

are: 1. To mix accurately the metallic calx to be reduced with the proper quantity of the matter which is to give it phlogiston. 2. To add to the mixture some saline or vitreous matter capable of facilitating the fusion and separation of the reduced metal from the scoria. 3. To prevent any communication with external air, that the phlogiston may not be burnt and consumed. 4. To keep the fire low at first, that the too great swelling, which is generally occasioned by the re-action of the inflammable principle with metallic earths, may be prevented; and to raise the fire towards the end, so that not only the metal, but also the supernatant scoria, may be perfectly fused; whereas if the scoria was not well fused and tenacious, it would retain much of the reduced metal, and prevent it from falling down to the bottom of the crucible.

The operations must be very exactly performed, especially in essays of ores, in which the precise quantity of metal is required to be known. These essays of ores are in some measure the only reductions of this kind which are performed in practical chemistry, as the reduction of pure metallic calxes differs only from the former in requiring a less quantity of flux; because these calxes do not, as the ores do, contain a difficultly fusible earthy or stony matter: we therefore refer to the article Essay *of* Ores. Here we shall only observe, that when we treat very volatile semi-metals, as zinc and arsenic, the reduction ought to be made in vessels perfectly close; for instance, in an earthen retort. We find after the reduction these metallic matters sublimed in the vault or neck of the retort.

The reduction of metals which do not lose their inflammable principle, as gold, silver, and mercury, is of another kind. As these metals can be only disguised by the union they have contracted with some heterogeneous substance, they are to be reduced, not by restoring phlogiston, but by some intermediate substance capable of separating from them the matter which is united with them. These intermediate substances must therefore differ according to the matter united with the metal.

For instance, fulminating gold may be reduced by fusing it with sulphur, or with fixed alkali; because either of these substances is capable of decomposing the nitrous ammoniacal salt which gives the fulminating property to gold. *See* Gold (Fulminating). Luna cornea also is reduced by fusing it with a large quantity, as, for instance, with twice its weight of fixed alkali; because in this reduction the marine acid united with the silver is to be separated, and the fixed alkali is capable of effecting that separation. The reduction of luna cornea is attended with difficulties, because this compound is semi-volatile and very penetrating; so that when it is exposed to fire, some part of it is always lost, whether it exhales in vapors or penetrates the crucible. Several chemists recommend the reduction of luna cornea by fusing it with fat matters, which, from experience, I know to be a very bad method; for the marine acid has a strong affinity with silver, and has no disposition to unite with phlogiston, or even with substances which contain much of it.

Luna cornea may also be well reduced by precipitation, and by treating it with other metals which have more affinity than silver with marine acid, such as tin, iron, regulus of antimony. Mr. Margraaf gives, in his *Opuscules Chemiques*, a process which deserves a place here; because, according to this excellent chemist,

mist, a very pure silver is obtained, and without any loss. It consists in mixing well, in a glass mortar, luna cornea with some concrete volatile alkali, in the proportion of about five gros of luna cornea with an ounce and a half of volatile salt, to which a little water is to be added to give to the mixture a soft consistence. This mixture swells with a kind of effervescence. After it has been triturated a quarter of an hour, three ounces of very pure mercury revived from cinnabar are to be added. The trituration is to be renewed for two or three hours, and half a gros of volatile alkali is to be added, to replace that which is dissipated; and afterwards a larger quantity of water. Upon the addition of this water appears a fine amalgam of silver, which is to be washed several times, till the water comes off clear. This amalgam is then to be distilled, by which the mercury is expelled, and all the silver which was contained in the luna cornea remains pure, excepting about four grains which have been washed away.

The mercury of cinnabar is to be reduced or separated from sulphur, by mixing with the cinnabar any substance which has greater affinity with the sulphur than mercury has, such as fixed alkalis, absorbent earths, iron, copper, lead, silver, or regulus of antimony. Filings of iron are generally employed in this operation, an equal weight of which is to be mixed with the cinnabar, and the whole distilled together, by which the mercury will be raised and collected at the bottom of the receiver under some water placed there to facilitate its condensation. The sulphur of the cinnabar remains in the retort united with the intermediate substance employed for the separation. This mercury is called *mercury revived from cinnabar*. It is justly considered as very pure.

DLXXXIII. REFINING. Refining is a term used in chemistry and several arts to signify the purification of some substance, particularly of metals, as gold, silver, copper, iron, &c.

We shall here treat only of the refining of gold and silver; and for the refining of other substances we refer to their several articles.

Gold and silver may be refined by several methods, which are all founded on the essential properties of these metals, and acquire different names according to their kinds. Thus, for instance, gold, having the property which no other metal, not even silver, has, of resisting the action of sulphur, of antimony, of nitrous acid, of marine acid, may be purified by these agents from all other metallic substances, and consequently may be refined. These operations are distinguished by proper names, as *purification of gold by antimony*, *parting*, *concentrated parting*, *dry parting*. In a similar manner, as silver has the property, which the imperfect metals have not, of resisting the action of nitre, it may be refined by this salt: but the term *refining* is chiefly applied to the purification of gold and silver by lead in the cupel. We shall therefore treat only of this latter manner of purifying these metals, referring for the others to the words PURIFICATION *and* PARTING. *See these words.*

The refining of gold and silver by lead in the cupel is made by the destruction, vitrification, and scorification of all the extraneous and destructible metallic substances with which they are allayed.

As none but the perfect metals can resist the combined action of air and fire, without burning, that is, without losing their inflammable principle, their metallic properties and forms, and without being changed into earthy or vitreous matters, incapable of remaining any longer united with substances in a metallic state, there

there is then a poſſibility of purifying gold and ſilver from all allay of imperfect metals merely by the action of fire and air; only by keeping them fuſed till all the allay be deſtroyed: but this purification would be very expenſive, from the great conſumption of fuel, and would be exceedingly tedious. I have ſeen ſilver allayed with copper, expoſed longer than ſixty hours to a glaſs-houſe fire without being perfectly refined: the reaſon of which is, that when a ſmall quantity only of imperfect metal remains united with gold or ſilver, it is covered and protected from the action of the air which is neceſſary for the combuſtion of the imperfect metals, as of all combuſtible matters. *See* CALCINATION.

This refining of gold and ſilver merely by the action of fire, which was the only method anciently known, was very long, difficult, expenſive, and imperfect: but a much ſhorter and more advantageous method has been diſcovered. This method conſiſts in adding to the allayed gold and ſilver a certain quantity of lead, and in expoſing afterwards this mixture to the action of the fire. Lead is one of the metals which loſes moſt quickly and eaſily enough of its inflammable principle to ceaſe to be in a metallic ſtate; but, at the ſame time, this metal has the remarkable property of retaining, notwithſtanding the action of the fire, enough of this ſame inflammable principle to be very eaſily melted into a vitrified and powerfully vitriſying matter, called *litharge*. *See* LITHARGE.

The lead then which is to be added to the gold and ſilver to be refined, or which happens naturally to be mixed with theſe metals, produces in their refining the following advantages: 1. By encreaſing the proportion of imperfect metals, it prevents them from being ſo well covered and protected by the perfect metals. 2. By uniting with theſe imperfect metals, it communicates to them a property it has of loſing very eaſily a great part of its inflammable principle. 3. Laſtly, by its vitrifying and fuſing property which it exerciſes with all its force upon the calcined and naturally refractory parts of the other metals, it facilitates and accelerates the fuſion, the ſcorification, and the ſeparation of theſe metals. Theſe are the advantages procured by lead in the refining of gold and ſilver.

The lead which in this operation is ſcorified, and ſcorifies along with it the imperfect metals, ſeparates from the metallic maſs, with which it is then incapable of remaining united. It floats upon the ſurface of the melted maſs; becauſe by loſing part of its phlogiſton, it loſes alſo part of its ſpecific gravity, and laſtly it vitrifies.

Theſe vitrified and melted matters accumulating more and more upon the ſurface of the metal while the operation advances, would conſequently protect this ſurface from the contact of air which is abſolutely neceſſary for the ſcorification of the reſt, and would thus ſtop the progreſs of the operation, which could never be finiſhed, if a method had not been contrived for their removal. This removal of the vitrified matter is procured either by the nature of the veſſel in which the melted matter is contained; and which being porous, abſorbs and imbibes the ſcorified matter as faſt as it is formed, or by a channel cut in the edge of the veſſel through which the matter flows out.

The veſſel in which the refining is performed is flat and ſhallow, that the matter which it contains preſents to the air the greateſt ſurface poſſible. This form reſembles that of a cup, and hence it has been called *cupel*. *See* PLATE I. *Fig.* 10. The furnace ought to be vaulted, that the heat may be applied upon the ſurface

 of

of the metal during the whole time of the operation. Upon this ſurface a cruſt or dark-colored pellicle is continually forming. In the inſtant when all the imperfect metal is deſtroyed, and conſequently the ſcorification ceaſes, the ſurface of the perfect metals is ſeen, and appears clean and brilliant. This forms a kind of *fulguration* or *coruſcation*. By this mark the metal is known to be refined. If the operation be ſo conducted that the metal ſuſtains only the preciſe degree of heat neceſſary to keep it fuſed before it be perfectly refined, we may obſerve that it fixes or becomes ſolid all at once in the very inſtant of the coruſcation; becauſe a greater heat is required to keep ſilver or gold in fuſion, when they are pure, than when allayed with lead.

The operation of refining may be performed in ſmall or in large quantities, upon the ſame principles, but only with ſome differences in the management. As the refining of ſmall quantities of perfect metals is performed in the ſame manner as theſe metals are eſſayed, the eſſay being only a very accurate refining, we refer to the article Essay *of the* Value *of* Silver.

Large quantities of ſilver are thus purified, after the operations by which that metal is obtained from its ores. This ſilver, being always much allayed, is to be mixed with a ſufficient quantity of lead to compleat its purification, unleſs lead has been added in its firſt fuſion from the ore, or unleſs it has been extracted from an ore which alſo contains lead; in which latter caſe, it is allayed naturally with a ſufficient quantity, or more than ſufficient, for the refining of it. *See* Ores *of* Silver. One of the ores of this kind, which is treated in the beſt manner, is the ore of Ramelſberg in Saxony. The ſeveral operations which are practiſed in this country, abounding in mines and excellent metallurgiſts, have been exactly deſcribed by Schlutter. We ſhall here give a ſuccinct extract of the method of purifying large quantities of ſilver, from Hellot's tranſlation of Schlutter's work.

The workmen give the name of *the work* to the lead containing ſilver, obtained by ſmelting the ore of Ramelſberg. The firſt operation, called *fining*, upon this maſs of lead and ſilver, is performed in a furnace called a reverberatory furnace, from the vaulted form, which makes the heat reverberate upon the ſurface of the metal. *See a plan and ſection of this furnace*, Plate II. *Fig.* 16 *and* 17. This furnace is ſo conſtructed, that the flame of the wood, which is put in the fire-place through a hole called the fire-hole, is directed ſo as to circulate over the *work* within the furnace. The flame is thus directed by a current of air which is introduced through the aſh-hole, and paſſes out at an opening made at the ſide of the place where the work is. The wood is conſiderably ſaved by this direction of the flame. In the furnace a large cupel or teſt is to be diſpoſed. This teſt is to be made with aſhes of beech wood well lixiviated, that the ſalt may be waſhed from them. *See* Cupel. In ſome founderies different matters are added to the aſhes, as ſand, lime, clay, calcined ſpar or gypſum. We may obſerve, concerning theſe additions, that they would be very injurious, and would make the teſt melt, if a ſtrong heat were applied; but the heat requiſite for fining is only moderate. *See at the word* Essay *the inconveniences and marks of too ſtrong a heat.*

When the teſt is well prepared and dried, all the *work* is to be put into it at once, which is generally ſixty-four quintals: the fire is then to be made in the fire-place with faggots; but the fuſion is not to be too much haſtened, firſt, that the teſt may have time to dry thoroughly, which is very eſſential; for if any

any moiſture remained when the metal is melted, an exploſion might happen: ſecondly, becauſe the *work* of the ore at Rameltberg, and of moſt others, is rendered impure by the mixture of many metallic matters, which ought to be ſeparated, otherwiſe they would ſpoil the litharge, and give a bad quality to the lead afterwards obtained from that litharge. Theſe extraneous matters found in the *work* of Ramelſberg are, copper, iron, and matt. As theſe ſubſtances are hard and refractory, they do not melt ſo ſoon as the *work*, if the heat be moderate; and beſides, as they are ſpecifically lighter than the mixture of lead and ſilver, they float upon the ſurface of theſe two metals when melted, in form of a pellicle or ſkin, which is to be taken off. Theſe impurities are called the ſcum or firſt droſs. The remainder forms alſo a ſcum, which appears when the work has received more heat, but before the litharge has begun to form. This is a ſcoria which is to be carefully taken off, and is called the ſecond droſs.

When the operation is come to this point, it is to be continued by means of bellows, the air of which is directed not on the wood, but on the ſurface of the metals, by means of iron plates placed for that purpoſe before the blaſt-hole, and which are called papillions. This air is not intended to encreaſe the fire, but to facilitate the combuſtion of the lead, and to puſh the litharge to a channel in the oppoſite ſide of the teſt. This channel is called *the way of the litharge*, becauſe through this paſſage all the litharge, which is not imbibed by the teſt, flows out of the furnace. The litharge which is found in the middle of the large lumps is friable, and crumbles into powder like ſand. It is put in caſks, each of which contains five quintals of it, and is ſold by the name of *ſaleable litharge*. It is uſed for various purpoſes, and particularly for glazing of earthen ware. The other part which remains is called *cold litharge*. It is remelted and reduced to lead. This fuſion is called *cold fuſion*, and the lead produced from it, called *cold lead*, is good and ſaleable, when the work has been well purified from the extraneous matters mentioned above. The teſts impregnated with litharge are added to the ſame kind of ore when ſmelted; becauſe they contain not only much litharge, which may be reduced to lead, but alſo ſome ſilver, in all refinings, whether in great or in ſmall, as Mr. Tillet obſerves.

When about two-thirds of the work are converted into litharge, no more of it is formed: the ſilver is then covered with a ſort of white ſkin, which the refiners call *lightening*; and they call the metal *lightened ſilver* or *fined ſilver*. The ſilver thus fined is not pure: every mark of it contains about four gros of lead: it is given to workmen, who compleat the purification of it in the ordinary method, that is, by a ſecond cupellation with a hotter fire; which latter purification is called *refining*, and the perſons who perform it are called *refiners*. The workmen employed in this firſt operation or fining give improperly the name *lightening* to the white ſkin formed on the ſurface of the ſilver, when brought only to a certain degree of fineneſs; for we know that in eſſays the lightening or coruſcation above-mentioned does not appear but when the ſilver is perfectly fine, or, at leaſt, as fine as it can be made by cupellation.

A fining of ſixty-four quintals of work of Ramelſberg yields about eight or ten marks of fine ſilver, thirty-five or forty quintals of litharge, that is, from twelve to eighteen of ſaleable litharge, from twenty-two to twenty-three of

cold litharge, from twenty to twenty-two quintals of tefts, and fix or feven quintals of drofs. The operation lafts from fixteen to eighteen hours.

If the filver before thefe operations was allayed with gold, it retains it ftill after the fining and refining. The gold, if the quantity be confiderable enough, may be feparated by parting. The operations for the purification of gold by cupellation are perfectly the fame as thofe of filver. If the gold to be fined contains filver, this filver remains with it after the operation; becaufe both thefe metals refift the action of lead. The filver may afterwards be feparated by parting.

DLXXXIV. R E F R A C T O R Y. This word is applied to unfufible fubftances, or thofe which cannot be melted in a violent fire.

DLXXXV. R E F R I G E R A T O R Y. A refrigeratory is a copper veffel foldered round the capital of the alembic. Its ufe is to contain cold water, which is to be renewed when it is heated, and the hot water is to be let out at a cock fitted to the refrigeratory for this purpofe. The intention of this renewal of the water of the refrigeratory is to keep perpetually cool the capital of the alembic, that the vapors of the liquor which rife in diftillation may be condenfed more eafily and more quickly. Thefe refrigeratories were much ufed formerly, and all alembics were furnifhed with them: but modern diftillers find that this veffel is not attended with the advantages formerly believed; for the diftillation cannot fucceed unlefs the capital of the alembic be as hot, or almoft as hot, as the cucurbit. Mr. Beaumé obferved, that when the capital was cooled by very cold water, the diftillation is foon ftopped, and does not again begin till the capital is confideraly heated.

The refrigeratory has for thefe reafons been much neglected, and a *worm* fubftituted in place of it, which is indeed a kind of refrigeratory, but different from the other in this refpect, that it is adapted to the nofe of the alembic, inftead of furrounding the capital. *See* ALEMBIC, DISTILLATION, *and* WORM. *See alfo* PLATE I. *Fig.* 8.

DLXXXVI. R E G I S T E R. Regifters are openings in different parts of furnaces, which are to be fhut occafionally with ftoppers of burnt clay. By means of regifters we may govern the fire as we pleafe; for by opening or fhutting them properly we may not only encreafe or diminifh the activity of the fire, but alfo we may apply its action more to one part of the furnace than another, by giving direction to the current of air which paffes thro' it. Notwithftanding the utility of regifters, they are much neglected. Many chemifts have difufed regifters, probably becaufe they did not find the advantages from them which they expected. The reafon of this is, that regifters have hitherto been ill made Their principal fault is, that they are generally too fmall. A regifter cannot have its proper effect unlefs it have an opening of two, three, or four inches, for a furnace, the internal diameter of which is a foot: but we frequently fee furnaces of eighteen or twenty inches diameter, with regifters, the openings of which are fcarcely eight or ten lines. Befides, all thofe who ufe furnaces are far from underftanding their conftruction. *See* FURNACE.

DLXXXVII R E G U L U S. The name *regulus* is given by chemifts to metallic matters when feparated from other fubftances by fufion. This name was introduced by alchemifts, who expecting always to find gold in the metal

metal collected at the bottom of their crucibles after fusion, called this metal thus collected, *regulus*, as containing gold, the king of metals. But although, since the cultivation of philosophical chemistry, these metallic masses composed of several metals mixed together are frequently called by this name, yet it is more particularly applied to certain semi-metals which have no proper name, such as the *regulus of antimony*, *regulus of arsenic*, and *regulus of cobalt*.

DLXXXVIII. REGULUS *of* ANTIMONY. Regulus of antimony is the semi-metallic substance contained in mineral antimony, after it has been separated by proper operations from the sulphur which mineralises it.

This semi-metal, when very pure and well fused, is of a white shining color, and is composed of laminæ applied to each other. It is one of the metallic matters which most easily takes the regular arrangement of parts which is proper to it. When it has been well fused, and afterwards cooled not too hastily, and when its surface is not obliged to conform to the shape of any solid matter which touches it during the time of its hardening, its regular arrangement becomes sensible both externally and internally. This kind of crystallisation forms then upon the upper surface of the regulus of antimony a sort of star, composed of many radii issuing from one center. Alchemists disposed to the marvellous, imagined this to be very mysterious and significative, and that it was nothing less than a star appearing to magi or sages to conduct them to the cradle of the king. But this wonder has been reduced by Stahl in his *Opusculum Chemicum*, and by Mr. Reaumur in a Memoir of 1724, to what it really is; that is, to the regular arrangement of the integrant parts of the regulus of antimony, when, by a perfect fusion and slow cooling, they have had time and opportunity to place themselves in that disposition to which they naturally tend from their primary form: and since that time, chemists have found that this phenomenon is common to all metallic matters, which form, in similar circumstances, not stars, because the integrant parts of each have peculiar shapes, but different figures no less regular and dependent on the form of these parts. It is an effect absolutely similar to the regularity of the figure of salts in their crystallization. *See* CRYSTALLIZATION.

Regulus of antimony is moderately hard, but, like the other semi-metals, it has no ductility, and breaks in small pieces under a hammer.

It loses $\frac{1}{7}$ part of its weight in water. The action of the air and of water destroys its lustre, as it does to all imperfect metals, but it does not destroy and rust it so effectually as it does copper and iron.

This semi-metal is fusible with a moderate heat, and as soon as it begins to be red-hot: but when it is heated to a certain degree, it fumes continually, and is dissipated in vapors, because it is semi-volatile, like the other semi-metals.

The fumes of regulus of antimony, when passing through air, form what are called *argentine flowers of regulus of antimony*. They are nothing but the earth of this semi-metal deprived of part of its inflammable principle, and capable of being reduced to the state of regulus by its union with this principle. *See* FLOWERS (ARGENTINE).

This regulus, by calcination with a moderate fire, is deprived of more and more of its phlogiston, and is changed successively first into a grey calx capable of being fused by a stronger heat either into a vitreous and brittle matter, but brown

brown or opake, or to a reddish transparent glass, according to its degree of calcination. The former matter is a *liver of antimony*, and the latter a *glass of antimony*. *See these words.*

If the calcination be continued longer, the calx of the regulus of antimony loses more and more of its phlogiston, color, volatility, fusibility; and, lastly, may be rendered similar to the white calxes of antimony prepared by more expeditious processes, called *diaphoretic antimony*, and *bezoard mineral.*

Nitre detonates with this semi-metal, and accelerates more or less, according to the quantity of it employed, but always considerably, these calcinations, as it does with all the imperfect metals.

Mineral acids dissolve regulus of antimony very difficultly. Aqua regia is the best menstruum of it. Nevertheless a very good combination of the marine acid with this metallic matter may be made by the process for butter of antimony. Sulphur acts upon regulus of antimony, with which it forms a compound not different from mineral antimony. Liver of sulphur dissolves it effectually, and forms with it an *antimoniated liver of sulphur*, more or less alkaline, from which a kermes mineral and golden sulphur of antimony may be obtained.

We only slightly mention here these preparations of regulus of antimony. As they are made most commonly, and even most conveniently, with antimony, they are more particularly described under the article ANTIMONY, and under the articles of the several names by which they are known.

Regulus of antimony is seldom found within the earth in any other state than mineralised by sulphur, and in form of antimony. Mr. Anthony Swab mentions, in the Memoirs of the Swedish Accademy for 1748, that he had found, in a mine near Salberg in Sweden, a regulus of antimony not mineralised.

Regulus of antimony is easily obtained pure and disengaged from sulphur, by the ordinary process for obtaining metallic matters from their ores, that is, by calcining them, and thus depriving them of their mineralising substances, sulphur and arsenic, and afterwards by fusing the metallic earth with a matter proper to give it phlogiston. Thus, by fusing the grey calx of antimony, for instance, with black flux or soap, we shall obtain a fine regulus of antimony, as Kunckel has shewn, and as Mr. Geoffroy afterwards practised. But the ordinary method of making small quantities of the regulus in laboratories, and described in books of chemistry, is more expeditious, because calcination is avoided. It consists in mixing four parts of crude antimony with three parts of tartar and one part and a half of nitre; in detonating this mixture, by parts, in a large red-hot crucible; and afterwards by raising the heat so as to produce fusion. When the crucible is cold, it is to be broken, and at the bottom may be found a regulus of antimony lying under a saline scoria, from which it is easily separated by the stroke of a hammer, as has been said under the word *antimony*.

The nitre added in this operation consumes quickly the largest part of the sulphur of the antimony. The tartar is burnt and alkalised. This alkali, mixed with a part of the alkali of the nitre, seizes a portion of the sulphur of antimony, with which it forms a liver of sulphur; and this liver dissolves in its turn a portion of the regulus of antimony, which consequently remains in the scoria. The scoria also contains a certain quantity of vitriolated tartar formed by the acid of the portion of sulphur, the phlogiston of which has been burnt during

during detonation, and by a part of the alkalis of nitre and of tartar. As tartar enters largely into this mixture, and as it contains much oil, a sufficient quantity of phlogiston remains (as the quantity of nitre used is but small) to reduce the earth of the antimony to a metallic state.

We may easily perceive that this fusion of the ore of regulus of antimony, with intention to separate from it the regulus, has no other advantage than that of being very expeditious, because the calcination, which is long, is avoided. But it does not procure all the metallic matter of the ore, since a part of it always is combined with the liver of sulphur in the scoria; and also as regulus of antimony is volatile, much of it is dissipated in fumes during the detonation. This method, therefore, which without this inconvenience would be well adapted for obtaining at once a metal from a crude ore, is evidently unfit for the purpose of essay, in which case, great care must always be taken that no liver of sulphur be formed during the operation. For this reason the ore must be deprived very accurately of all its sulphur by torrefaction before it is fused. Some chemists even avoid the use of alkaline fluxes, as the black and white fluxes, in fusions for essays of ores, because a small quantity of sulphur frequently adheres strongly to the ore, notwithstanding the calcination; and this method is certainly the safest and most accurate. But when the precise quantity of metal contained in the ore is not required, we may conveniently use this fusion of crude mineral with crude flux, as is usually done for the obtaining of regulus of antimony in chemical laboratories.

Regulus of antimony is one of the most important metallic matters, because it furnishes some very powerful remedies. When taken in substance, it is emetic and purgative, but is uncertain in its effects, because it only acts when it is dissolved, or corroded by the substances it meets in the primæ viæ, and because these solvents are very various, according to the nature of the aliments, and also to the variable state of the temperament. When the use of antimony was first introduced, small globules of the regulus were taken internally, which passed through the intestinal canal, and lastly were thrown out of the body along with the evacuations which they occasioned. As these globules or pills were neither diminished nor altered sensibly after these operations, and as they were capable of serving an indefinite number of times, they were called *perpetual pills*. Cups also were made of the regulus of antimony, in which wine being left, acquired a purgative quality; but as the wine dissolved more or less in proportion to the quantity of acid contained in it, and as wine is very various in this respect, hence the effects of this wine were not more certain than those of the perpetual pills. Since the discovery of better antimonial preparations, these ancient remedies have been neglected. Their uncertainty, and even the dangerous accidents which they frequently occasion, have undoubtedly contributed not a little to the opposition that many physicians, otherwise persons of merit, made for a long time to the use of antimony, when it was first introduced into medicine. The famous quarrels excited concerning antimony are well known. On both sides of this contest there were some reason and some error. They who rejected the use of antimony certainly erred in proscribing a substance capable of furnishing so excellent remedies; and the most zealous partisans of it were too extravagant in their praises, at a time when its qualities and the methods of preparing it were not well known, and when

when the effects of the antimonials then adminiſtered were ſo uncertain and dangerous.

Regulus of antimony is alſo uſeful in many arts. It enters into the compoſitions for metallic ſpeculums of teleſcopes, and for printing types.

According to Mr. Geoffroy's table of affinities, it unites with metals in the following order. Iron, copper, ſilver, and lead; and according to Mr. Gellert, with zinc, iron, copper, tin, lead, ſilver, biſmuth, gold.

DLXXXIX. REGULUS (MARTIAL) *of* ANTIMONY, *or* REGULUS *of* ANTIMONY PRECIPITATED *by* METALS. Regulus of antimony has much leſs affinity with ſulphur than moſt other metallic matters, as iron, copper, tin, lead, ſilver, and biſmuth. Accordingly, when crude antimony is fuſed with a ſufficient quantity of any of theſe metals, the reguline part may be ſeparated from the ſulphur. A true precipitation is then made by the dry way. As iron, of all metals, has moſt affinity with ſulphur, it is preferable to any other for the ſeparation of regulus of antimony by this precipitation.

The proceſs uſed for that purpoſe conſiſts in making ſome horſeſhoe-nails white-hot in a crucible (theſe nails being ſoft iron and eaſily fuſible with ſulphur), to which is to be added twice their weight of crude antimony, and in procuring by a ſtrong heat a fuſion of the whole, after having covered the crucible. The iron which unites with the ſulphur of the antimony is by its means perfectly fuſed; and, being rendered lighter than the reguline part of the antimony then deprived of ſulphur, riſes to the upper part of the melted maſs, while the regulus ſinks to the bottom.

If the fuſion has been compleat, we ſhall find upon breaking the crucible, when cold, a fine regulus of antimony covered with a hard ſcoria, which is a combination of iron with the ſulphur of antimony. The moſt eſſential point to be attended to in this operation is to give a ſufficient heat for a perfect fuſion; but as this heat muſt be very ſtrong, moſt of the proceſſes directed in books for the preparation of this regulus, order the addition of a quantity of nitre equal to a fifth part of the antimony employed, as ſoon as the fuſion commences. This nitre detonates with the phlogiſton of the ſubſtances contained in the mixture, its detonation makes it conſiderably more fluid, and this nitre, when alkaliſed, mixing with the ſcoria, forms a liver of ſulphur, which diſſolves a portion of the metals, and makes the ſcoria more fluid by giving to it a ſaline quality.

Lemery and many others direct, that the regulus ſhould be afterwards fuſed thrice, and that in the firſt of theſe three fuſions an eighth part of crude antimony, with the ſame quantity of nitre as in the former fuſion, ſhould be added, and the nitre only in the two latter fuſions.

The crude antimony added in the ſecond fuſion is intended to carry off by means of its ſulphur a part of the iron which may be united with the regulus, and the nitre which is to be added in each of the following fuſions is intended to purify further the regulus from any remaining portion of ſulphur. The intention then of all theſe preparations is only to obtain a pure regulus of antimony, which may be obtained otherwiſe much more eaſily. *See the preceding article.*

DXC.

DXC. REGULUS *of* ARSENIC. This is white arsenic, to which the properties of a semi-metal have been given, by combining it properly with a sufficient quantity of phlogiston.

Regulus of arsenic may be made by several methods. The process anciently used for this purpose consisted in mixing four parts of arsenic with two parts of black flux, one part of borax, and one part of filings of iron, or of copper, and quickly fusing the mixture in a crucible. When the operation is finished, a regulus of arsenic will be found at the bottom of the crucible, of a white livid color, and considerably solid. The iron and copper employed in this process are not intended, as in the operation for the martial regulus of antimony, to precipitate the arsenic, and to separate it from sulphur or any other substance; for the white arsenic is pure, and nothing is to be taken from it, but, on the contrary, the inflammable principle is to be added to reduce it to a regulus. The true use of these metals in the present operation is to unite with the regulus of arsenic, to give it more body, and to prevent its entire dissipation in vapors. Hence the addition of iron, while it procures these advantages, has the inconveniency of altering the purity of the regulus: for the metallic substance obtained is a regulus of arsenic allayed with iron. It may, however, be purified from the iron by sublimation in a close vessel; by which operation the regulised arsenical part, which is very volatile, is sublimed to the top of the vessel, and is separated from the iron, which, being of a fixed nature, remains at the bottom. We are not, however, very certain that in this kind of rectification, the regulus of arsenic does not carry along with it a certain quantity of iron; for in general a volatile substance raises along with it, in sublimation, a part of any fixed matter with which it happened to be united.

Mr. Brandt proposes another method, which we believe is preferable to that described. He directs that white arsenic should be mixed with soap. Instead of the soap, olive oil may be used, which I have found to succeed well. The mixture is to be put into a retort or glass matrass, and to be distilled or sublimed with a fire at first very moderate, and only sufficient to raise the oil. As the oils, which are not volatile, cannot be distilled but by a heat sufficient to burn and decompose them, the oil therefore which is mixed with the arsenic undergoes these alterations, and after having penetrated the arsenic thoroughly, is reduced to a coal. When no more oily vapors rise, we may then know that the oil is reduced to coal. Then the fire must be encreased, and the metallised arsenic will be soon sublimed to the upper part of the vessel, in the inside of which it will form a metallic crust. When no more sublimes, the vessel is to be broken, and the adhering crust of regulus of arsenic is to be separated. The regulus obtained by this first operation is not generally perfect, or not entirely so, as a part of it is always overcharged with fuliginous matter, and another part has not enough of phlogiston, which latter part adheres to the inner surface of the crust, and forms grey or brown crystals. This sublimate must then be mixed with a less quantity of oil, and sublimed a second time like the first; and even, to obtain as good a regulus as may be made, a third sublimation in a close vessel, and without oil, is necessary. During this operation, the oil which rises is more fetid than any other empyreumatic oil, and is almost insupportable. This smell certainly proceeds from the arsenic, the smell of which is exceedingly strong and disagreeable, when it is heated.

Regulus of arsenic, made by the method I have described, and which I consider as the only one which is pure, has all the properties of a semi-metal. It has metallic gravity, opacity, and lustre. Its color is white and livid, it tarnishes in the air, is very brittle, but much more volatile than any other semi-metal. It easily loses its inflammable principle, when sublimed in vessels into which the air has access; the sublimate having the appearance of grey flowers, which by repeated sublimations become entirely white, and similar to white crystalline arsenic.

When regulus of arsenic is heated quickly and strongly in open air, as under a muffle, it burns with a white or bluish flame, and dissipates in a thick fume, which has a very fetid smell, like that of garlic.

Regulus of arsenic may be combined with acids and most metals. As white arsenic also can unite with these substances, we refer to that article. We shall only observe here, that, according to Mr. Brandt, in the Swedish Memoirs, the regulus of arsenic cannot be united with mercury. Altho' the phenomena exhibited by white arsenic and regulus of arsenic in solutions and allays are probably the same, yet an accurate comparison of these would deserve notice, especially if the regulus employed were well made; for some difference must proceed from the greater or less quantity of phlogiston with which it is united. *See* ARSENIC.

DXCI. REGULUS *of* COBALT. Regulus of cobalt is a semi-metal lately discovered, and not yet perfectly well known. It receives its name from cobalt, because it can only be extracted from the mineral properly so called.

The process by which this semi-metal is obtained is similar to those generally used for the extraction of metals from their ores. The cobalt must be thoroughly torrefied to deprive it of all the sulphur and arsenic it contains, and the unmetallic earthy and stoney matters must be separated by washing. The cobalt thus prepared is then to be mixed with double or triple its quantity of black flux, and a little decrepitated sea-salt, and must be fused either in a forge or in a hot furnace. For this ore is very difficult of fusion.

When the fusion has been well made, we find upon breaking the crucible, after it has cooled, a metallic regulus covered with a scoria of a deep blue color. The regulus is of a white metallic color. The surface of its fracture is close and small grained. This semi-metal is hard, but brittle. When the fusion has been well made, its surface appears to be carved with many convex threads which cross each other diversely. As almost all cobalts contain also bismuth, and even as much as of the regulus itself, this bismuth is reduced by the same operation, and precipitated in the same manner as the regulus of cobalt; for although these two metals are frequently mixed in the same mineral, that is, in cobalt, they are incapable of uniting together, and are always found distinct and separate from one another when they are melted together. At the bottom of the crucible then we find both regulus of cobalt and bismuth. The latter, having a greater specific gravity, is found under the former. They may be separated from each other by the blow of a hammer. Bismuth may be easily distinguished from the regulus of cobalt, not only from its situation in the crucible, but also by the large shining facets which appear in its fracture, and which are very different from the close, ash-colored grain of regulus of cobalt.

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This semi-metal is more difficult of fusion than any other, is less easily calcinable, and much less volatile. Its calx is grey, and more or less brown; and when fused with vitrifiable matters, it changes into a beautiful blue glass called *smalt*. This calx then is one of those which preserve always a part of their inflammable principle. It is soluble in acids as the regulus is. This regulus is soluble in vitriolic, marine, nitrous acids, and in aqua regia, to all which it communicates colors. The solution in vitriolic acid is reddish; the solution in marine acid is of a fine bluish-green when hot, and its color is almost totally effaced when cold, but is easily recoverable by heating it, without being obliged to uncork the bottle containing it. This solution of the calx or regulus of cobalt is the basis of the sympathetic ink, for without marine acid this ink cannot be made. *See* INK (SYMPATHETIC).

All the solutions of regulus of cobalt may be precipitated by alkalis, and these precipitates are blue, which color they retain when vitrified with the strongest fire.

Not only sympathetic ink, but also regulus of cobalt, may be made from the *zaffre* commonly sold, which is nothing else than the calx of regulus of cobalt mixed with more or less pulverised flints. For this purpose we must separate as well as we can the powder of flints from it by washing, as Mr. Beaumé does, and then reduce it with black flux and sea-salt.

Regulus of cobalt seems incapable of uniting with sulphur; but it easily unites with liver of sulphur, and the union it forms is so intimate, that Mr. Beaumé could not separate these two substances, otherwise than by precipitation with an acid.

Many curious and interesting remarks are still to be discovered concerning this singular semi-metal, and we may hope to receive further information from the endeavors of chemists who have undertaken the examination of it. Mr. Beaumé particularly has made considerable experiments on this subject, part of which he communicates to the public in his Course of Chemistry. All the new remarks in this article are from him. We wish that this able chemist would publish the numerous experiments he has made on this subject. *See* COBALT, INK (SYMPATHETIC), AZURE, ZAFFRE, *and* SMALT.

DXCII. RESIN. The name *resin* in its most general sense might be applied to all solid or concrete oily substances, not only those particularly called *resins*, as *mastich*, *sandarach*, *white pitch*, &c. but also to wax, butter, fat, &c. But these concrete oily matters differ so much from each other, that they ought to be more particularly distinguished.

First, we may observe, that every solid oily substance owes its consistence to a saline, and especially to an acid matter; for we know that a liquid oil may be rendered thick by the addition of an acid, in proportion to the quantity of acid, and intimacy of combination. We also know, that by decomposing concrete oils by distillation, we obtain a quantity of acid so much greater, or so much stronger, as this oil is thick or more solid; or at least, that the quantity of liquid oil obtained by this distillation is proportionable to the quantity of acid separated.

But all concrete oils may be naturally combined with a sufficient quantity of acid, to give it this consistence, in two manners; for either they have received originally from nature a sufficient quantity of acid, or else, being formed originally fluid, they have lost by evaporation the part which is the most thin, most volatile, and least charged with acid, or least perfectly combined with acid; by which the proportion of well combined acid is more and more encreased in the portion which is not evaporated, and which is therefore rendered thicker.

According to this distinction, concrete oils are naturally divided into two classes, the former comprehending those which are always found in a solid state, as wax, butter, and the fat of animals, and the latter comprehending the thickened or consolidated residuums of oils, which, from a liquid state, have become concrete by the dissipation and evaporation of their most fluid part. This second class includes all concrete oils, to which the name of resins has been applied. The properties of all concrete oils of the former class shew incontestably that these oils, or oily concretions, are of the kind of oils which are most sweet, most unctuous, least inflammable, and least volatile. Accordingly, all these matters resemble each other essentially, and only differ from one another by their greater or less solidity: but the resins or concrete oils of the second class are very different from one another, some of them having a strong aromatic smell, and dissolving easily and entirely in spirit of wine, and others having little or no smell, at least when cold, and being totally unsoluble in spirit of wine; such as *gum-copal*. These properties so different amongst substances, confounded under one general name, shew that the liquid oils whence they were formed were essentially different. The former resins ought to be considered as the residuums of essential oils and natural balsams, since they evidently retain the principal properties of these. The latter can only be the residuums of certain oils not volatile, unsoluble in spirit of wine, but capable of becoming rancid, thick, and dry; as oil of linseed, hemp, nuts, &c. for these oils, kept a long time in a dry place, in open shallow vessels, become concrete, transparent, deprived of all smell, and unsoluble in spirit of wine, like the resin called *gum-copal*. Natural resins of this latter class are much rarer than those of the former, because more vegetables have a superabundant essential oil than a superabundance of drying oil, which is not volatile; or, at least, this second kind of oil is less easily evaporable than the former.

Resinous matters have not been sufficiently examined. We might probably find many of them similar to copal, and also others, which, proceeding from the two kinds of oils above described, mixed and evaporated together, would partake at the same time of the two kinds of resins resulting from these, and would hold a similar relation to the two kinds of resins which gum-resins hold to gums and resins. Amber and other solid bitumens, which also are oily concrete matters, unsoluble in spirit of wine, and evidently of vegetable origin, are probably formed by oils not volatile, thickened and hardened by age, or by intimate combination with mineral acids.

Resins, being only thickened balsams, are collected, as these balsams are, upon trees and plants from which they have exsuded. Several of them are obtained by art. Such is the *black pitch*, which is obtained by making it melt

and

and exsude, by means of heat, from firs, pines, and other trees of this kind, which contain large quantities of it. Such also are the resins of jalap, scammony, and turpeth, which are obtained for medicinal uses, by digesting the vegetables containing them previously well dried, in spirit of wine, from which they are afterwards separated by adding a large quantity of water.

Resins are employed for many purposes. The cheapest kinds are used for torches, and to cover the outsides of ships and boats. The fine, transparent resins compose varnishes. Many of them are employed medicinally; either externally, as, for instance, those which enter into the composition of ointments and plasters; or internally, as the resins of scammony, jalap, turpeth, which are purgative. Other resins, the smell of which is agreeable, as, for instance, benjamin and storax, are employed as perfumes. *See the articles* BALSAMS, BITUMENS, OILS, *and* GUM-RESINS. *See also the Dictionary of Natural History for the particular detail of the different kinds of resins and their uses.*

DXCIII. RETORT. Retorts are vessels employed for many distillations, and most frequently for those which require a degree of heat superior to that of boiling water. This vessel is a kind of bottle with a long neck so bent, that it makes with the belly of the retort an angle of about sixty degrees. From this form they have probably been named *retorts*. The most capacious part of the retort is called its *belly*. Its upper part is called the *arch* or *roof of the retort*, and the bent part is the *neck*. See PLATE I. *Fig.* 1. *and* 2.

Retorts differ in form and materials: their bellies are generally round: some of them are oblong and shaped like a cucurbit: these are called *English retorts*. They are preferable for the distillation of matters which are subject to swell and to pass into the receiver before they be decomposed.

A retort which has a little hole pierced in its roof is called a *tubulated retort*. This hole must be capable of being exactly closed with a stopper of proper materials. Retorts of this kind are employed in distillations, where some matter must be introduced into the retort after the receiver is joined to it, as in the distillation of smoking marine acid, and in the operations for procuring the several kinds of *clyssus*.

If the retort be well made, the above-mentioned inclination of its neck must be most favorable to distillation. When the neck is too much inclined, the receiver cannot be conveniently luted to it, and is also by this form brought too near the furnace. If the neck be too little inclined, the vapors or liquors which rise in distillation can scarcely flow into the receiver from want of sufficient descent, and only circulate in the belly of the retort. Retorts, when too strait in their bending, are very faulty. This form must be an impediment to distillation: the passage therefore from the belly to the neck of the retort must be free and wide, and gradually diminishing to the extremity of the neck or the mouth of the retort.

Retorts of different materials are used in chemical operations, of common glass, crystal-glass, stone-ware, iron. Retorts of glass are used for all operations which require a less heat than is sufficient for their fusion. Earthen retorts are necessary where great heat is requisite, as in the preparation of phosphorus. Iron retorts are not much used, as they can only serve for the distillation

lation of substances which cannot act upon this metal, and as these substances are few in number. They can seldom be employed but for the distillation of mercury and of animal matters.

DXCIV. REVERBERATORY. *See* FURNACE.

DXCV. REVIVIFICATION. *See* REDUCTION.

DXCVI. RHUBARB. (*n*)

DXCVII. RISIGAL. The same as REALGAR.

DXCVIII. ROASTING *of* ORES. *See* SMELTING *of* ORES.

DXCIX. ROSEMARY. (*o*)

DC. RUBIN *of* ANTIMONY. This is a kind of liver of antimony, made with equal parts of nitre and crude antimony detonated together, to which is afterwards added an equal part of common salt; but as the addition of the salt is useless, the preparation is not now employed. It is also called *magnesia opalina*. *See* ANTIMONY *and* LIVER *of* ANTIMONY.

DCI. RUBY (ARSENICAL). This preparation is red realgar, to which, by fusion and cooling, a transparency is given which makes it resemble a ruby; in which respect only it differs from realgar. *See* REALGAR.

(*n*) RHUBARB. An ounce of Rhubarb, reduced into gross powder, yielded with highly rectified spirit of wine three drams of extract, and afterwards with water two drams, two scruples and a half: the residuum weighed two drams twelve grains. By applying water first to another ounce, five drams, two scruples and a half of extract were obtained, and of the residuum five grains only were soluble in spirit of wine. Rhubarb appears from these experiments to contain much more gummy or mucilaginous than resinous matter; and hence spirituous tinctures of it are not precipitated or rendered milky by addition of water, like the tinctures of most other vegetables.

The yellow color of rhubarb is remarkably less destructible than many other vegetable yellows. Aqua fortis and other acids, which destroy the color of saffron, turmeric, &c. make no change in that of rhubarb, or at most render it only turbid. Volatile spirits heighten the color, and incline it to red. Fixed alkaline salts have this effect in a greater degree. Solutions of green vitriol and other chalybeate liquors, change the color of infusions of rhubarb to an inky blackness; a mark that this root is possessed of an astringent quality. The spirituous extract does not purge, although the extract made by water after spirit does, as if its purgative quality resided chiefly in a combination of gummy and saline matter. *Neuman.*

(*o*) ROSEMARY. The only active principle in this plant is the essential oil. The gummy extract, divested of the oil, has no remarkable taste any more than smell. The resinous extract retains a considerable part of the flavor of the herb, and of the essential oil. Its fragrance is communicated by infusion or by distillation to spirit or to water. Vinous spirit, impregnated by distillation with the flavor of rosemary, is called *Hungary-water*. The flowers of this plant contain little or no smell, and no oil could be collected from the distilled water: but from forty-eight ounces of leaves, three drams and half a scruple of oil were obtained by distillation. Tournefort observes, that those sorts of rosemary, which produce neither flowers nor seeds, and which have very hard shrubby stalks and long narrow leaves, smell strongly like camphor, and yield, on distilling a large quantity for the purpose of obtaining their oil, a portion also of actual camphor. *Neuman.*

DCII.

DCII. R U S T. This name is particularly applicable to the earth of iron decomposed by the action of water and of air; but it may be given to the earth of any other metal capable of such decomposition, as copper, and all other metallic matters, excepting the perfect metals. Thus verdegrise might be called the rust of copper. The kind of *cerus* formed upon lead, exposed to a humid air, may be called *rust of lead*, &c. *See the articles of the several metallic matters.*

S.

DCIII. **S** A F F R E. *See* Zaffre.

DCIV. S A F F R O N. (*p*).

DCV. S A F F R O N *of* I R O N. Chemists have given the name *saffron* to many preparations which have a yellow color, like that of saffron, and particularly to the earth or rust of iron which has that color.

As iron may be deprived of its phlogiston by the combined action of air and of water, by that of air and fire, and, lastly, by acids, different names have been given to saffrons of Mars, or ferruginous earths prepared by these several agents. The rust of iron made by humid air is called *martial saffron prepared with dew*, or *aperitive saffron of Mars*. Iron, dephlogisticated by vitriolic acid or sulphur, is also called *aperitive saffron of Mars*. Lastly, that which is reduced into a calx by the action of fire, is called *astringent saffron of Mars*. *See, for the medicinal virtues of these preparations of iron, the articles* Ethiops Martial *and* Iron.

As the saffrons of iron acquire different shades of red and orange colors, which they preserve when melted with very fusible vitrified matters, they are employed for painting on enamel, on pottery, porcelain, and for giving color to glass, or imitations of precious stones.

(*p*) Saffron. Both water and spirit extract the color and virtue of saffron. The former liquor improves the smell and heightens the color, whilst the spirit seems rather to weaken both. By drying two ounces and a half of the best saffron in the heat of a water-bath, half an ounce of liquor was obtained, which had an exceeding strong smell, but had not the appearance of oil. This is the active part of the saffron, which disorders the head and senses. Six drams of extract were obtained from an ounce of dried saffron by means of water, and five drams and one scruple were obtained from another ounce by means of spirit. Rectified spirit acquired no smell or taste by distillation from dried saffron; but water being thus distilled acquired a strong smell. *Neuman.*

DCVI. SAFFRON *of* METALS. Saffron of metals is the metallic earth of antimony, half deprived of its sulphur and phlogiston by detonation of crude antimony with nitre, and afterwards well washed; or it is liver of antimony deprived of all saline matter by a sufficient washing. This preparation is a violent and uncertain emetic, not used by prudent physicians. *See* LIVER *of* ANTIMONY, *and* TARTAR (EMETIC).

DCVII. SALMIAC. This word is an abridgement used by some for sal ammoniac. *See* AMMONIAC (SAL).

DCVIII. SALT. The word salt, which is synonimous with saline matter or saline substances, when taken in its most general sense, is of all chemical terms that which is applicable to the greatest number of individuals. In fact, the number of different bodies, which have what chemists call a saline character, or which possess the principal saline properties, is so great that they are very far from being all known, as we shall afterwards see.

The essential properties of all matter, which ought to be considered as saline, are, to affect the sense of taste, to be soluble in water, and to have all the principal qualities, as gravity and fixity, in an intermediate degree betwixt those of water and of pure earth.

If we attend a little to the principal properties of the several bodies which are considered as salts or saline substances, we shall easily find that they do not all possess in the same degree the essential saline qualities that we have described. We shall see that some salts possess these qualities in the highest degree, while in others they are so weak and indistinct, that in many of them they can scarcely be discovered; and this diminution of the saline properties is so considerable in many compound bodies, that we may affirm that the limits which separate saline matters from others that are not saline, are unknown, indeterminate, and perhaps incapable of being determined.

We are certain, on the other side, that the saline substances whose properties are most distinct and strong, such, for instance, as the mineral acids, have great power over many other substances which have not a saline property; to which, by being combined together, they communicate more or less of their saline properties; or rather with which they form compounds, in which the saline properties are more or less sensible. Since experience shews that these saline compounds may be decomposed, so that the substance, which is not saline, shall be separated in its former state from the saline matter, which also shall recover the saline properties in the same force which it had before this union, we may from thence conclude;

First, that among the infinite multitude of bodies in which we may perceive saline properties, a very great number are composed of a substance essentially saline, and of one or more other substances not saline.

Secondly, that we ought to distinguish well substances which essentially possess saline properties from those which, not possessing any such properties themselves, are only capable of receiving more or less of them by uniting with substances of the former kind.

Thirdly, as the number of matters not saline which are capable of acquiring a saline character, or rather of forming compounds more or less saline by their union with substances essentially saline, is very great, the number of these last

muſt be very ſmall, in compariſon of the number of compounds in which ſaline properties are perceptible.

To give ſome explanation of this extenſive ſubject, we muſt begin by determining preciſely what ſubſtances eſſentially ſaline are, and by aſſigning a character which can diſtinguiſh them from thoſe, which, without containing any thing ſaline, may nevertheleſs make part of ſalts, by the union they are capable of contracting with the former. Theſe characters are the following:

All thoſe ſubſtances ought to be conſidered as eſſentially ſaline which have not only the characteriſtic properties of ſalts, as taſte and perfect miſcibility with water, in an eminent degree, but which alſo when diſengaged can communicate theſe properties, at leaſt in part, to other ſubſtances which have them not, by combining with theſe latter, from which, when afterwards ſeparated, they reſume their former ſtate and peculiar ſaline characters.

All acids and alkalis, mineral, vegetable, or animal, fixed or volatile, fluid or concrete, muſt be conſidered as ſubſtances eſſentially ſaline. Each of theſe bodies has the properties we have mentioned. Some other ſubſtances have not the properties of acids or of alkalis very diſtinctly; but as they have the properties of ſalts in general, and are capable of acting as acids, and of communicating ſaline properties to the compounds into which they enter, they may therefore be conſidered as ſubſtances eſſentially ſaline. Such are *arſenic* and *ſedative ſalt*.

But if we reflect a little on the particular properties of each of the ſubſtances which ſeem to be eſſentially ſaline, we ſhall obſerve that they do not all poſſeſs theſe properties in the ſame degree. How great the difference is in this reſpect betwixt pure, concentrated vitriolic acid and the acid of tartar! They can ſcarcely be known to be ſubſtances of the ſame kind. The taſte ſimply acidulous of cream of tartar, its ſtate of conſtant cryſtallization and dryneſs, its little ſolubility in water, laſtly, the weakneſs of the adheſion which it contracts with all the ſubſtances with which it can unite, cannot be compared with the ſtrong and corroſive taſte of vitriolic acid, with the activity of its ſeizing moiſture, with the ſurprizing heat occaſioned by its mixture with water, laſtly, with the extreme force that keeps this body united to all the bodies with which it is capable of combining. The ſlighteſt view of the other ſubſtances eſſentially ſaline is ſufficient to ſhow that they differ much from each other, particularly in their degree of ſtrength; in a word, that they do not poſſeſs the ſaline properties in the ſame degree.

Theſe are the conſiderations which have undoubtedly determined the greateſt chemiſts, particularly Stahl, to believe that the number of ſubſtances truly and eſſentially ſaline is very ſmall, and even that only one ſaline principle exiſts, which by the intimate union it is capable of contracting with ſeveral other ſubſtances, conſtitutes a certain number of matters which poſſeſs the ſaline properties in a degree ſufficiently ſtrong to preſerve theſe properties more or leſs in their ſeveral combinations with other matters that are not ſaline, and to recover them entirely when ſeparated from theſe combinations; ſo that as they do not themſelves undergo any decompoſition, and as they always appear again with the ſame properties after having been combined and ſeparated, they ſeem to be ſimple matters, eſſentially ſaline, although they really are compounds of

ſeveral

ſeveral bodies, not ſaline, united intimately with one only ſaline principle, which is univerſal and always the ſame.

According to this notion, which is grand and perfectly analogous to the plan which nature ſeems conſtantly to purſue in the different orders of compounds, the queſtion is to diſcover which is the moſt ſimple of all ſaline ſubſtances, and is the principle of all others. The beſt, and perhaps the only, method of determining in a queſtion of this nature, is to compare together the ſeveral ſaline ſubſtances, and to conſider that as the moſt ſimple of all, which poſſeſſes the ſaline properties in the moſt eminent degree, and which alſo appears upon all occaſions to be leaſt ſuſceptible of decompoſition or alteration; for all chemiſtry ſhews us, that theſe are the characters of the moſt ſimple bodies, which are capable of becoming principles of more compound bodies: but when we examine all the ſaline matters under this point of view, we ſhall ſoon eaſily diſcover that we muſt begin by excluding all the ſaline matters called *neutral ſalts*; for any of theſe ſalts may be decompoſed by ordinary chemical operations; and theſe decompoſitions ſhow that many of them are compoſed of two ſimpler ſaline ſubſtances, one of which is called *acid*, and the other *alkali*; alſo, acids and alkalis are not in general ſo eaſily altered as neutral ſalts. In the claſſes therefore of theſe two ſaline ſubſtances, we muſt ſearch for that which is the moſt pure and ſimple of all.

If we continue this inquiry upon the ſame principles, and compare together the ſaline properties of the pureſt and ſtrongeſt acids and alkalis, we ſhall eaſily be convinced that the ſaline properties are ſtronger and more diſtinct in acids than in alkalis, ſince the former are more active, more diſſolving, more adhering to the bodies diſſolved, more deliqueſcent, &c. and alſo, that in the ſeveral operations of chemiſtry, alkalis fixed and volatile appear to be more ſuſceptible of alteration and decompoſition than acids. Amongſt acids, therefore, we muſt ſearch for the ſtrongeſt and ſimpleſt ſaline matter.

Laſtly, when we examine in the ſame manner, and compare together all the ſubſtances which have the principal properties of acids, and which are called acids, we ſhall clearly perceive that thoſe which are truly vegetable and animal, that is, in the combination of which oil enters, are infinitely more weak and ſuſceptible of alteration than acids deprived of all oil, which we call mineral acids; amongſt which, the vitriolic will be eaſily diſcovered to be the ſtrongeſt and moſt unalterable, and conſequently of all bodies which have ſaline properties, the pureſt, ſimpleſt, and the moſt ſenſibly and eſſentially a ſalt.

Such conſiderations have undoubtedly induced the moſt profound chemiſts, and eſpecially the illuſtrious Stahl, to conſider this acid as the pureſt and ſimpleſt of all ſaline matters; and indeed all who are capable of reflecting on the greateſt and moſt important phenomena of chemiſtry, will conſider this propoſition as a demonſtrated truth. But Stahl carries this notion ſtill farther. From his writings, and the whole of his doctrine, we may infer, firſt, "That "he conſiders the vitriolic acid as the only ſubſtance eſſentially ſaline; as the "only ſaline principle, which, by uniting more or leſs intimately with other "ſubſtances that are not ſaline, is capable of forming an innumerable multi-"tude of the other ſaline matters which nature and art ſhew to us; and,

" secondly, that this saline principle is a secondary principle, composed only of " the intimate union of two primary principles, *water* and *earth*."

Every true chemist will easily discover that this grand idea is capable of comprehending by its generality, and of connecting together, all the phenomena exhibited by saline substances. But we must at the same time acknowledge, that when we examine the proofs upon which it is founded, although it has a great appearance of truth by its consistency with the principles of chemistry, and with many phenomena, yet it is not supported by a sufficient number of facts and experiments to ascertain its truth.

We might here examine what degree of probability ought to be granted to this theory of salts, but this could not be properly accomplished without entering into long details, and penetrating into the depths of chemistry; in a word, without making a full and compleat treatise, which cannot be admitted in a work of this nature. We are therefore obliged to relate only what is most essential to be known concerning this grand hypothesis. We may perceive at once, that the former of these propositions, upon which is founded the theory which we mentioned, cannot be demonstrated, unless it be previously proved that every saline matter, excepting pure vitriolic acid, is nothing but this same acid differently modified, the primary properties of which are more or less altered or disguised by the union contracted with other substances. But we confess, that chemists are not capable of proving decisively this opinion; which, however, will appear very probable from the following reflections.

First, of all saline matters known, none is so strong, so unalterable, so eminently possessed of saline properties, as *vitriolic acid*.

Secondly, amongst the other saline substances, those which appear most active, and most simple, as *nitrous* and *marine acids*, are at the same time those, whose properties most resemble the properties of vitriolic acid.

Thirdly, we may give to vitriolic acid many of the characteristic properties of nitrous acid, by combining it in a certain manner with the inflammable principle, as we see in the volatile sulphureous acid. *See* ACID (VOLATILE SULPHUREOUS), *and* ACID (NITROUS): and even, according to an experiment of Mr. Piech, related in a Memoir concerning the origin of nitre, which gained the prize of the Academy of Berlin, vitriolic acid, mixed with vegetable and animal matters susceptible of fermentation, is really transformed into a nitrous acid by the putrefaction of these matters.

Fourthly, the marine acid, altho' its principles are less known than those of the nitrous acid, may be approximated to the character of vitriolic and nitrous acids by certain methods. This acid, after it has been treated with tin and other metallic matters, is capable of forming ether with spirit of wine, as vitriolic acid does, which it cannot do in its natural state; and when iron is dissolved in it, it seems to be approximated to the nature of nitrous acid. Reciprocally, the approximation of vitriolic acid to the character of marine acid seems not impossible. Having once distilled very pure vitriolic acid upon a considerable quantity of white arsenic, I was struck with a strong smell like that of marine acid, which was not either that of arsenic or of vitriolic acid; for this has no smell, when it is pure.

Fifthly, oily vegetable acids become so much stronger, and more similar to vitriolic acid, as they are more perfectly deprived of their oily principle, by combining

combining them with alkalis, earths, or metals, and afterwards by separating them from these substances, by distillation, and especially by frequently repeating these operations. They might perhaps be reduced to a pure vitriolic acid, by continuing sufficiently this method: and reciprocally, vitriolic and nitrous acids weakened by water, and treated with much oily matters, or still better with spirit of wine, acquire the characters of vegetable acids. We may see a remarkable instance of this in Mr. Pott's *Dissertation de Acido Nitri Vinoso*.

Sixthly, the properties of fixed alkalis seem to be very different from those of acids in general, and consequently of vitriolic acid. Yet if we consider that a large quantity of earth enters their composition; that much of it may be separated by repeated solutions and calcinations; and also that by depriving these saline substances of their earthy principle, they become less fixed, more deliquescent, and, in a word, more similar to vitriolic acid in this respect; we shall not think it improbable, that fixed alkalis owe their saline properties to a saline principle of the nature of vitriolic acid, but much disguised by the quantity of earth, and probably of inflammable principle, to which it is united in these combinations. The properties of volatile alkalis, and the transformation of fixed alkali or of its materials into volatile alkali in putrefaction and in several distillations, seem to shew sufficiently that they are matters essentially saline, as fixed alkalis are, and that their volatility which distinguishes them proceeds from their containing a less quantity of earth, but more attenuated, and a portion of very subtle and volatile oil, which enters their composition.

Besides these principal facts, there are many others, too numerous to be even slightly mentioned here: they may be found scattered in the works of chemists, particularly of Stahl. But persons who would collect and compare all the experiments relating to this subject, ought to know, that many of them are not sufficiently ascertained, and that perhaps a greater number of them have not been sufficiently prosecuted, and are, properly speaking, only begun. We must even acknowledge, that many of those experiments which we have mentioned have not been sufficiently prosecuted. *See all the articles of acids and alkalis.*

The second fundamental proposition of the theory of salts, namely, "that "the vitriolic acid is compounded of only the aqueous and earthy principles," is, like the first, supported by many facts which give it a degree of probability, but which do not amount to a compleat demonstration. This proposition may be supported by the following considerations.

First, experience constantly shews, that the properties of compound bodies are always the result of those of the component parts of these bodies, or rather they are the properties of these component bodies modified by one another.

Thus, if a body be composed of two principles, one of which is fixed and the other volatile, it will have a less degree of fixity than the former, and a less volatility than the latter. If it be composed of two principles, one of which is specifically heavier than the other, its specific gravity will be greater than that of one of them, and less than that of the other. The same observation is applicable to all the other essential properties, excepting those which destroy each other, as, for instance, the tendency to combination, or the dissolving power; for these latter properties are weakened so much more in the compounds, as their principles are more strongly united, and in more just proportion.

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We observe nevertheless, that the properties of compound bodies are not always exactly intermediate betwixt the properties of the component bodies; for, to produce this mean, the quantities of each of the component parts must be equal, which is the case in few or no compounds.

Besides, some particular circumstances in the manner in which the principles unite with one another, contribute more or less to alter the result of the combined properties; for instance, experience shews, that when several bodies, particularly metals, are united together, the specific gravities of which are well known, the allay formed by such union has not the precise specific gravity which ought to result from the proportion of the allayed substances; but that in some allays it is greater, and in others less. But we are certain, on the other side, that these differences are too inconsiderable to prevent our distinguishing the properties of the principles in the compounds which they form, especially when they have very different properties.

These things being premised, when we examine well the properties of vitriolic acid, we shall easily find that they partake of the properties of the aqueous and of the earthy principles.

First, when this acid is as pure as we can have it, it is like the purest water and the purest vitrifiable earths, free from color or smell, and perfectly transparent.

Secondly, although we cannot deprive the vitriolic acid of all the water superabundant to its saline essence, and therefore its precise specific gravity has not been determined, we know that when it is well concentrated, it is more than twice as heavy as pure water, and much less heavy than any earthy substance.

Thirdly, this acid is much less fixed than any pure earth, since, however well it may be concentrated, it may always be entirely distilled; for which purpose, a much stronger degree of heat is requisite than for the distillation of pure water.

Fourthly, we do not know the degree of solidity of vitriolic acid, or the *adhesion of aggregation* which its integrant parts have one to another, because for this purpose the vitriolic acid ought to be deprived of all superabundant water; but if we judge of it by the solid consistence of this acid when highly concentrated, as we see from the vitriolic acid called *glacial*, the integrant parts of this acid seem susceptible of a much stronger adhesion than those of pure water, but much less than those of earth, as we see from the instance of hard stones.

Fifthly, the union which this acid contracts with water and with earths, shows that these substances enter into its composition: for we know that in general compounds are disposed to unite superabundantly with the principles which compose them. All these properties of vitriolic acid, which so sensibly partake, and much more than any other acid, of the properties of earth and of water, are sufficient to induce us to believe that it is composed of these two principles; but it has one very eminent property, which is common with it to neither water nor pure earth, which is, its violent and corrosive taste. This property is sufficient to raise doubts, if we could not explain it from principles which seem certain and general, relating to the combination of bodies. We shall here summarily recapitulate them, although we have spoken of them in several articles

articles of this work, particularly at the words AFFINITY, AGGREGATION, SOLUTION, COMPOSITION, GRAVITY, SATURATION.

We obſerve then concerning the property now in queſtion, that is, of taſte in general, that it can only be conſidered as an irritation made upon the organs of taſte by ſapid bodies: and if we reflect attentively upon it, we ſhall be convinced that no ſubſtance that is not impreſſed by ſome impulſe, can irritate or agitate our ſenſible organs, but by a peculiar force of its integrant parts, or by their tendency to combination, that is, by their diſſolving power. According to this notion, the taſte of bodies, or the impreſſion made upon our ſenſible organs by their tendency to combination, or by their diſſolving power, are the ſame property; and we ſee accordingly, that every ſolvent has a taſte which is ſo much more ſtrong, as its diſſolving power is greater; that thoſe whoſe taſte is ſo violent that it amounts to acrimony, corroſion, and cauſticity, when applied to any other of the ſenſible parts of our body beſides the organs of taſte, excite in them itching and pain.

This being premiſed, the queſtion is, how earth, in which we perceive no taſte nor diſſolving power, and water, which has but a very weak diſſolving power, and little or no taſte, ſhould form by their combination a ſubſtance, ſuch as the vitriolic acid is, powerfully corroſive and ſolvent?

To conceive this, let us conſider firſt that every part of matter has a power by which it combines, or tends to combine with other parts of matter. Secondly, that this force, the effects of which are perceptible, in chemical operations, only among the very ſmall molecules, or the integrant and conſtituent parts of bodies, ſeems proportionable to the denſity or ſpecific gravity of theſe parts. Thirdly, that this ſame force is limited in every integrant molecule of matter; that if we conſider this force as not ſatisfied, and conſequently as a ſimple tendency to combination, it is the greateſt poſſible in an integrant molecule of matter perfectly inſulated, or attached to nothing, and is the ſmalleſt poſſible, or none, when it is ſatisfied by its intimate combination with other parts capable of exhauſting all its action; its tendency is then changed into adheſion.

Hence we may infer, that the integrant parts of the earthy principle have eſſentially, and, like all the other parts of matter, a force of tendency to union, or of coheſion in union, according to their condition; that as this earthy principle has a much more conſiderable denſity or ſpecific gravity than all other ſimple bodies that we know, we may probably preſume that its primary integrant molecules have a more conſiderable force of tendency to union, in the ſame proportion, than the integrant parts of other principles; that conſequently when they cohere together, and form an aggregate, their aggregation muſt alſo be ſtronger and firmer than that of any other body. Accordingly we ſee that the pureſt earthy ſubſtances, whoſe parts are united and form maſſes, ſuch as, for inſtance, the ſtones called vitrifiable, are the hardeſt bodies in nature. We are no leſs certain, that as the tendency of the parts of matter to unite is ſo much leſs evident as it is more exhauſted and ſatisfied in the aggregation, the parts of the earthy principle being capable of exhauſting mutually all their tendency to union, we may thence infer, that every ſenſible maſs of pure earthy matter muſt appear deprived of any diſſolving power, of taſte, in a word, of tendency to union, from the firmneſs of its aggregation. But we may alſo infer, that when theſe primary integrant parts of the earthy principle are not united

united together in aggregation, then, reſuming all the activity and tendency to union which are eſſential to them, they muſt be the ſtrongeſt and moſt powerful of all ſolvents.

Theſe being premiſed, if we ſuppoſe again, with Stahl and the beſt chemiſts, that in the combination of the ſaline principle or of vitriolic acid, the parts of the earthy principle are united, not with each other, as in the earthy aggregation, but with the primary parts of the aqueous principle, each to each, we may then eaſily conceive that the primary integrant parts of the water, having eſſentially much leſs tendency to combination than thoſe of earth, the tendency of theſe latter to union will not be exhauſted, but ſatisfied only partly, by their combination with the former, and that conſequently a compound muſt reſult, the integrant parts of which will have a ſtrong diſſolving power, as vitriolic acid is.

We may ſee from hence how much miſtaken chemiſts are, who, conſidering earth only in its aggregation, or rather not attending to this ſtate, and not diſtinguiſhing it from that ſtate in which the parts of this ſame earth are ſo ſeparated from each other by the interpoſition of another body, that they cannot touch or cohere together, have conſidered the earthy principle as a ſubſtance without force or action, and have very improperly called that a *paſſive principle*, which of all others is the ſtrongeſt, moſt active, and moſt powerful.

However this general theory of ſalts may conform with the moſt important phenomena of chemiſtry, we muſt acknowledge that it can only be propoſed as a ſyſtematical opinion, till it be evidently demonſtrated by the deciſive means employed in chemical demonſtrations, namely, by decompoſition and recompoſition: thus, if we could reduce vitriolic acid to earth and water, and make that acid by combining together theſe two principles, this theory would ceaſe to be a ſyſtem, and would become a demonſtrated truth. But we muſt confeſs that this theory is leſs ſupported by experiment than by argument, from the many difficulties that are inevitable in ſuch inquiries. For on one ſide, we know that the ſimpler bodies are, the more difficult is their decompoſition; and on the other ſide, the ſtronger the aggregation is, the greater is the difficulty of making it enter into a new combination. Thus, as vitriolic acid is very ſimple, ſince it is a compound of the firſt order, it ought ſtrongly to reſiſt decompoſition; and as the aggregation of pure earth is the firmeſt that we know, it cannot eaſily be made to enter as a principle into a new combination with water to form a ſaline matter. The following are the principal experiments which have been made relative to this ſubject.

Firſt, we ſeem to be certain, from many proofs, that all ſaline ſubſtances, comprehending thoſe that contain vitriolic acid, as vitriolated tartar, Glauber's ſalt, and other vitriolic ſalts which are ſufficiently fixed to ſupport a perfect drying, or rather calcination, being alternately diſſolved, dried, and calcined a number of times, are more and more diminiſhed in quantity, and that earth and water are ſeparated from them each operation. But alkaline ſalts appear to be ſtill more ſuſceptible than any other ſaline matter of this kind of decompoſition.

Secondly, when nitre is burnt in cloſe veſſels, ſo that we may retain not only all that remains fixed after this burning, but alſo what exhales in vapors, as in the experiment of the clyſſus of nitre, we have a proof which ſeems deciſive, that

that the mineral acid of this salt, which is not very far from the simplicity of vitriolic acid, is totally decomposed and reduced into earth and water. For if we examine the fixed residuum in the retort, we find that it is only the alkali that was contained in the nitre, charged with a superabundant earth, which is separable from it by solution and filtration. And if the liquor in the receiver, formed by the vapors condensed there, be examined, which ought to be nitrous acid, if this acid had not been destroyed, we find that, so far from being acid, it is only pure water, sometimes even charged with a little fixed alkali, which had been raised by the force of the detonation. Thus nitrous acid is made to disappear in this experiment, and in its place we find only earth and water. *See* ACID (NITROUS), CLYSSUS *of* NITRE, DETONATION *of* NITRE, *and* NITRE.

Thirdly, the phenomena of limestone, which by calcination and extinction in water acquires saline properties that it had not before, its attenuation by fire, and its combination with water; and also the experiment of Becher, who asserts, that if a vitrifiable stone be alternately made red-hot and extinguished in water a number of times, it may be so attenuated, that it shall be like a saline gelatinous matter; these, I say, shew that saline matters are actually formed by the intimate combination of the very attenuated parts of earth with those of water. We find in the writings of Becher and Stahl, and particularly in the *Specimen Beccherianum* of the latter author, many other observations and experiments tending to prove the same proposition; but we must confess that none of the experiments we have mentioned, excepting that of the decomposition of nitrous acid by burning, are absolutely decisive, principally because they have not been sufficiently repeated, or prosecuted, nor carefully enough examined in all their circumstances.

Such is the actual state of the best theory of saline substances hitherto given. However fine and probable it may seem, it requires to be further illustrated, and better proved, especially by experiments. They who love inquiries into the sublimest parts of chemistry cannot engage in a more interesting subject.

As substances essentially saline, and particularly those of their combinations which are called *salts*, are very numerous, we shall here merely enumerate them, that we may have them at one view. For the details we refer to the particular article of each of these saline matters. We shall see by this kind of view, that although many combinations are known, many also are not known, because they have never been made; and many others are known but imperfectly, because they have not been sufficiently examined.

Substances essentially saline are, acids, alkalis, and neutral salts with basis of alkali.

The simplest and strongest acids, called *mineral acids*, are, *vitriolic acid*, called also *universal acid*, or *saline principle*:

Nitrous acid, commonly called *spirit of nitre* or *aqua fortis*:

Marine acid, called also *spirit of salt*, and *acid of common salt*. See *all these articles*.

The acids less simple and less strong than the mineral acids are those which have entered into the combinations of vegetables and animals, and which are united to a certain quantity of oil more or less attenuated. These are crystallized

essential acid salts, such as *tartar*, called *cream* or *crystals of tartar*, when it is purified. *See* TARTAR.

The *acid of vinegar*, which proceeds from an acid fermentation, and is itself not only oily, but also spiritous. *See* VINEGAR.

The *unfermented acids of sharp fruits and plants*, as the juice of *gooseberries*, *citrons*, *sorrel*, &c. These acids have not been examined.

The acids and acid spirit, obtained in the distillation of vegetables, of their extracts, essential salts, oils, balsams, and resins. As all these acids are united to an empyreumatic oil, they may be called *empyreumatic acids*. They have not been examined.

The *acids obtained from animal substances* are;

The acid obtained in the distillation of *ants*, *flies*, and other *insects*; and the acid obtained in the distillation of *butter* or of *fat*. These acids are empyreumatic; they are very volatile, pungent, and penetrating. They have not been examined. *See* BUTTER *and* FAT.

Phosphoric acid, the origin and nature of which are not so well known that we can determine to what kingdom it belongs. *See* PHOSPHORUS *of* KUNCKEL, *and* SALT (FUSIBLE) *of* URINE.

Alkalis or *saline alkaline substances* are,

The fixed alkali of common salt, called also *mineral* or *fossil alkali*, *marine alkali*, *crystals and salt of soda*, because it is obtained by lixiviation and crystallization, from the ashes called *soda*.

Vegetable, or *common fixed alkali*. It is often called salt of tartar, or alkali of tartar, in the works of chemists, because the ashes of tartar furnish the largest quantity of it. Both these fixed alkalis are called *caustic fixed alkali*, when they have been altered by quicklime, or by metallic calxes. *See* ALKALI (FIXED).

Volatile alkali. That is called *fluor volatile alkali* which has been altered by quicklime, or by metallic calxes, so that it afterwards cannot be obtained in a solid or concrete form. *See* ALKALI (VOLATILE).

NEUTRAL SALTS.

Formerly those only were called neutral salts which were composed of acids and alkalis united together to the point of saturation, so that they had no acid or alkaline property, and thence they were called neutral. But now this name is commonly extended to combinations of acids with all substances with which they can so unite, that they lose entirely, or mostly, their acid qualities, as, for instance, when they are united with earthy or metallic substances. We shall enumerate these neutral salts, observing the order of the acids already enumerated.

VITRIOLIC SALTS.

Vitriolic acid combined with marine alkali forms a salt known by the name of *Glauber's salt*, or *sal mirabile*.

With fixed vegetable alkali it forms a salt called *vitriolated tartar*, *sal de duobus*, and *arcanum duplicatum*. *See these names.*

With volatile alkali, it forms an ammoniacal salt, called *vitriolic ammoniacal salt*, and *secret sal ammoniac of Glauber*. *See* AMMONIAC (SALT).

With calcareous earths, it forms *vitriolic salts with basis of calcareous earth*, known by the general name of *selenites*. *See that word.*

With argillaceous earth, it forms a *vitriolic salt with basis of argillaceous earth*, called *alum*. *See* ALUM.

With metallic substances, it forms different *vitriolic salts with metallic bases*, to which we ought to give the general name of *vitriol*, together with the name of the particular metal subjoined. Thus;

With gold, a salt little or not known, which may be called *vitriol of gold*.

With silver, a salt but little known, *vitriol of silver*.

With copper, a salt known by the name of *vitriol of copper*, or *blue vitriol*.

Vitriols are in commerce more generally called *copperas*. Accordingly, this is called *blue copperas*. It is also sometimes named *cyprian vitriol*.

The same acid with iron forms *vitriol of iron*, called *green* or *martial vitriol*, or *green copperas*.

With tin, it forms a salt little known, a *vitriol of tin*.

With lead, a salt little known, a *vitriol of lead*.

With quicksilver or mercury, a salt not yet well known, a *vitriol of mercury*.

With regulus of antimony, a salt little known, a *vitriol of regulus of antimony*.

With bismuth, a salt little known, a *vitriol of bismuth*.

With zinc and calx or flowers of zinc, a *vitriol of zinc*, known by the name of *white vitriol*, *white copperas*, *vitriol of Goslar*.

With regulus of cobalt, a *vitriol of cobalt*, very little known. Mr. Beaumé has begun to examine it.

With regulus of arsenic and arsenic, a *vitriol of arsenic*, or *arsenical vitriol*, very little known. *See the articles* ACID (VITRIOLIC) *and* VITRIOL, *and those of the saline alkalis*, *earths*, and *metallic substances*.

NITROUS SALTS.

Nitrous acid, combined with all the substances of which we have just mentioned the combinations with vitriolic acid, forms salts to which we may give the general names of *nitre* or *nitrous salt*, specifying each salt by the name of the substance united with the acid.

Nitrous acid with fixed vegetable alkali forms *ordinary nitre*, or *saltpetre*.

With marine alkali it forms *cubic* or *quadrangular nitre*.

With volatile alkali, *nitrous ammoniacal salt*, or *ammoniacal nitre*.

With calcareous earths, *nitre with basis of calcareous earth*.

With argillaceous earths, *nitre with basis of argillaceous earth*, a kind of *nitrous alum* little known.

With metallic substances, *metallic nitres*.

With gold, *nitre of gold*, unknown.

With silver, *nitre of silver*, *lunar nitre*, *lunar crystals*, or *crystals of silver*.

With copper, *nitre of copper*, or *cupreous nitre*.
With iron, *nitre of iron*, or *martial nitre*.
With tin, *nitre of tin*, unknown.
With lead, *nitre of lead*, or *crystals of lead*.
With mercury, *nitre of mercury*, *mercurial nitre*, *crystals of mercury*.
With regulus of antimony, *nitre of antimony*, unknown.
With bismuth, *nitre of bismuth*, *crystals of bismuth*.
With zinc, its calx and flowers, *nitre of zinc*, unknown.
With regulus of cobalt, *nitre of cobalt*, not much known. Mr. Beaumé has begun to examine it.
With arsenic and its regulus, *nitre of arsenic*, or *arsenical nitre*, very little known. *See* NITRES (METALLIC), *or with* METALLIC BASES. *See also the articles* ACID (NITROUS), *the articles of all the substances we have mentioned, and those of the nitrous salts which have particular names.*

MARINE SALTS, *or simply*, SALTS.

Marine acid forms with all these substances salts which may be called by the general name of *marine salts*, or simply *salts*, and specified by the names of their particular bases. Thus,

With marine alkali, it forms *common salt*, *kitchen salt*, *sea-salt*, when extracted from the sea, and *sal gem* when dug from the earth.

With fixed vegetable alkali, *common salt with basis of vegetable alkali*, called *febrifugal salt of Sylvius* improperly, because it is no more febrifugal than any other; and still more improperly called *regenerated sea-salt*, because it differs essentially from sea-salt by the nature of its basis.

With volatile alkali, it forms *sal ammoniac*, formerly *armoniac*, and by some chemists called *salmiac*.

With calcareous earths, a *salt with basis of calcareous earth*. As this salt is obtained in the decomposition of sal ammoniac by means of quicklime, or other calcareous earths, chemists have improperly called the salt made in this manner *fixed ammoniac*, when it is dry; and *oil of lime*, when it is liquid.

With argillaceous earths, it forms a *salt with basis of argillaceous earth*, very little or not known.

With metallic substances, it forms *salts with metallic bases*, specified by the name of each base. Thus,

With gold, it forms a *salt of gold*, unknown.

With silver, it forms a *salt of silver*, known by the name of *luna cornea*.

With copper, it forms a *salt of copper*, not much examined.

With iron, a *salt of iron*, or *martial salt*, not much examined.

With tin, a *salt of tin*. This combination, like those of the marine acid with metallic matters, may be made by dissolving immediately the metal in the acid: but it may be still better made by decomposing, with the assistance of heat, and by means of the metal intended to be united with the marine acid, a combination already made of this acid with some other metallic substance; which is always possible when the affinity of the metal to be combined is greater than that of the metal already combined. Thus we may form easily a crystal-

lizable

lizable salt of tin, by dissolving this metal directly in marine acid in the usual manner: this salt is but little known. The same combination is made by decomposing corrosive sublimate by means of tin, and by distillation. Thus we may obtain a combination of tin with marine acid, one part of which passes with excess of acid in form of a very smoking liquor, called *smoking spirit of Libavius*; and the other part which does not smoke, and which contains a larger proportion of tin, is sublimed in a solid state, and is called *butter of tin.*

With lead, *salt of lead*, known also by the name *plumbum corneum.*

With mercury, *salt of mercury.* It has different names according to the manner of making it, and according to the proportions of marine acid and mercury. It is called *white precipitate*, when it is separated from the nitrous acid by means of marine acid; *mercury corrosive sublimate*, or simply, *corrosive sublimate*, when it is actually sublimed, and with such proportions of mercury and acid, that a very corrosive salt results from them; *sweet mercury, sweet sublimate*, and *aquila alba*, when sublimed with an additional quantity of mercury by which its corrosive quality is blunted.

With regulus of antimony, it forms an *antimonial salt* by distillation. It is called *butter of antimony.*

With bismuth, it forms a *salt of bismuth*, not much examined.

With zinc, and its calx and flowers, a *salt of zinc*, little known.

With regulus of cobalt, a *salt of cobalt*, also little known.

With arsenic and its regulus, a *salt of arsenic*, or *butter of arsenic*, little known.

We may observe concerning all these combinations of marine acid with metallic matters, that, as this acid is very volatile, and as it is capable of adhering strongly with these substances, it does accordingly carry along with it more or less of them in sublimations and distillations; which is the reason that these salts are variable, as to the proportions of acid and metal which unite together, or which remain united, either directly by solution, or by distillation and sublimation, as we see from the phenomena exhibited by corneous metals, as tin and regulus of antimony. Although chemists, and still more, alchemists, have operated much on certain combinations of metallic substances with marine acid, much yet remains to be done to illustrate this subject.

We may here observe, that aqua regia, composed of nitrous and marine acids, which is in general a great solvent of metallic matters, must form with many of them mixed salts, some of which are perhaps of peculiar natures: but these combinations do not seem to have been examined hitherto as salts, no more than many others, as we may easily see from the present enumeration. *See the articles* ACID (MARINE), *and of the several substances with which we have mentioned its combinations.*

TARTAREOUS SALTS.

We shall give this name to the combinations of the acid of tartar, or of other concrete vegetable acids analogous to it, with the several substances capable of uniting with these acids. But very few of these salts are known, which are in general called *soluble tartars*, because they are all more soluble in water than the acid of tartar itself.

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The combination of cream of tartar with fixed vegetable alkali forms a neutral cryſtallizable ſalt, called *ſoluble tartar*, *tartariſed tartar*, and *vegetable ſalt*. *See this latter word.*

With marine alkali, it forms the ſalt known by the name of *ſalt of Seignette*, *ſal polychreſt*, *ſalt of Rochelle*.

With volatile alkali, a *ſoluble ammoniac tartar*, unknown.

With calcareous earths, *ſoluble tartars with baſis of calcareous earth*, very little known, but which appear ſimilar to the *ſoluble tartars with baſis of fixed alkali*.

With argillaceous earths, *ſoluble tartars with baſis of argillaceous earth*, unknown.

With metals, *ſoluble tartars with metallic baſes*, *ſoluble tartars of gold*, *of ſilver*, &c. which are all unknown, excepting the ſoluble tartars with baſis of *iron* and of *glaſs of antimony*. The former is deliqueſcent, and called, when liquid, *tartariſed tincture of iron*, or *of Mars*; and when evaporated, *martial extract*. It ought to be called *ſoluble martial tartar*. *See* TARTAR (SOLUBLE), and *the other names here mentioned*. The ſecond ſoluble tartar with metallic baſis is called *emetic* or *ſtibiated tartar*. *See* TARTAR (EMETIC).

ACETOUS SALTS.

We ſhall give this name to all ſalts containing the acid of vinegar.

With fixed vegetable alkali, it forms a *deliqueſcent ſalt*, called improperly *terra foliata tartari*, and *regenerated tartar*.

With marine alkali, it forms a cryſtallizable ſalt not much known, to which no name has been given. It may be called *acetous ſalt with baſis af marine alkali*.

With volatile alkali, an *acetous ammoniacal ſalt*, imperfectly known, and named *ſpirit of Mindererus*.

With calcareous earths, ſeveral *acetous ſalts with calcareous baſes*, very ſimilar one to another, and ſuſceptible of cryſtallizing, and forming beautiful *ſilky vegetations*, ſome of which are ſuperficially known, and named *ſalts of chalk*, *of crabs eyes*, *of coral*, &c.

With argillaceous earths, *an acetous argillaceous ſalt*, unknown.

With metallic ſubſtances, an *acetous ſalt with metallic baſis*, *of gold*, *ſilver*, &c. which are all unknown, excepting the three following:

With copper, an *acetous ſalt of copper*, known in chemiſtry by the names, *cryſtals of Venus*, or *of verdigriſe*, and in commerce and arts by the name *diſtilled*, or *cryſtallized verdigriſe*.

With lead, an *acetous ſalt of lead*, known by the name of *ſalt*, or *ſugar of lead*.

With mercury, an *acetous mercurial ſalt*, lately ſo named, but little known.

VEGETABLE SALTS.

This general name may be given to all neutral ſalts compoſed of the *acid juices*, *concrete ſalts*, *natural* or *unfermented acids of vegetables*, with the ſeveral ſubſtances

substances capable of uniting with these acids; but none of these salts are yet known.

VEGETABLE EMPYREUMATIC SALTS.

Neither do we know any thing of the salts which might be formed with the acids obtained by the distillation of vegetable matters, which furnish acid spirits or concrete acids, and which might be called *vegetable empyreumatic salts.*

ANIMAL EMPYREUMATIC SALTS.

By this name we may distinguish neutral salts composed with acids obtained from the distillation of animal matters, as the *acids of insects*, *of butter*, and *of fat*; but all these salts are perfectly unknown.

Although we have given the epithet *empyreumatic* to salts formed with vegetable and animal acids, obtained by distillation of these substances with a heat greater than that of boiling water, we do not mean to imply, that these salts, if they were well made and purified, would retain an empyreumatic character, or any part of the burnt oil which adheres to these acids after distillation. On the contrary, these acids may be deprived entirely or partly of this oil by passing into combinations of neutral salts, as happens to volatile alkalis when transformed into ammoniacal salts: but in this case we should be better able to examine the nature of these acids, and the epithet empyreumatic would only refer to the manner of obtaining them, and would serve to distinguish them from those vegetable or animal salts, the acids of which have been obtained without distillation in a naked fire.

PHOSPHORIC SALTS.

By this general name we mean all salts produced by combining the acid of *phosphorus of urine* with alkaline, earthy, and metallic substances, a small part of which salts is known even imperfectly.

With fixed vegetable alkali, this acid forms a *phosphoric salt*, a kind of *fusible salt of urine.*

With marine alkali, it forms another *phosphoric salt*, or *fusible salt of urine with basis of marine alkali.* It is not known.

With volatile alkali, a *phosphoric ammoniacal salt*, called also *fusible salt of urine*, *native salt of urine*, *microcosmic salt.*

With calcareous and argillaceous earths, *phosphoric*, *calcareous*, *and argillaceous salts*, not known.

With metallic substances, *phosphoric metallic salts of gold*, *silver*, *copper*, &c. very little known. *See the article* PHOSPHORUS.

Besides the saline substances which have sensible acid properties, some substances, as sedative salt and arsenic, without having these properties, do

nevertheless

nevertheless act as acids in their combinations with all substances capable of uniting with true acids, of forming with these substances kinds of neutral salts, and even of communicating, like the acids properly so called, saline properties to those substances which have them not. These combinations are by general consent classed amongst neutral salts.

BORAX, *or* SALTS *of* BORAX.

The sedative salt, combined with marine alkali, forms *ordinary borax*.

With fixed vegetable alkali, a kind of *borax*, not much known.

With volatile alkali, an *ammoniacal borax*, not much known.

With calcareous and argillaceous earths, *calcareous* and *argillaceous borax*, unknown.

With metals, *borax with metallic bases of gold*, *silver*, &c. unknown.

ARSENICAL SALTS.

Arsenic forms, with fixed vegetable alkali, a neutral salt perfectly soluble in water, and crystallizable, called by Mr. Maoquer, who first observed it, *neutral arsenical salt*, or simply *arsenical salt*. *See* ARSENIC, *and* SALT (NEUTRAL ARSENICAL).

With marine alkali, another arsenical salt, very like the former, but not much examined.

With volatile alkali, an *arsenical ammoniacal salt*, unknown.

With calcareous and argillaceous earths, a *calcareous* or *argillaceous arsenical salt*, unknown.

With metallic substances, arsenic is perhaps capable of forming *arsenical salts with metallic bases*, or combinations in which saline properties would be perceptible, if these combinations were made by decomposing nitrous salts with metallic bases by means of arsenic, or by precipitating metals dissolved in acids by means of a solution of neutral arsenical salt in water; but perhaps from thence nothing would be produced but combinations similar to the arsenical minerals. We are quite ignorant upon this subject.

Saline alkaline substances, besides the salts which they can form with acids, can also act upon earths and metals, with which they form saline compounds, and from which, when separated, they appear as before. Accordingly, these compounds may for this reason be ranked amongst salts, and general and particular denominations may be assigned to them, according to the principles which compose them, as, for example, *alkaline earthy salts*, *calcareous*, *argillaceous*, *vitreous*, *metallic*, as of *gold*, *silver*, &c. But hitherto chemists have not considered them in this view, and have even examined them but little.

Lastly, acids, alkalis, and even several neutral salts may, by combining with oily substances, form compounds which may be considered as true salts, if this name be given, as it ought to be, to every thing that is sapid and soluble in water: but these compounds form in some measure a distinct class, and are distinguished by the name of *soap*. *See* SOAP.

From

From this enumeration of ſaline compounds we may ſee how many of them are little known, or not even thought of. The numerous experiments yet to be made in this extenſive part of chemiſtry are nevertheleſs very neceſſary, and are fundamental and elementary. To make them ſucceſsfully, nothing is requiſite but accuracy, patience, and knowledge of the firſt principles of chemiſtry. Every intelligent perſon is capable of making them. For this purpoſe the acids, alkalis, earths and metals employed muſt be very pure, the ſaline compounds reſulting from their union muſt be examined; their taſte, ſolubility in water, cryſtallization, deliqueſcence, and the methods of decompoſing them muſt be obſerved. Theſe conſiderations are certainly ſufficient to excite the zeal of perſons who would contribute to the progreſs of chemiſtry.

We now proceed to treat ſummarily of the principal ſalts known by the name of ſalts, in an alphabetical order.

ACID SALTS.

Some chemiſts, and particularly ancient chemiſts, have thus named the ſaline ſubſtances which we only call *acids*. *See* Acids. We may however continue this name, and apply it to ſome concrete ſaline ſubſtances, as *tartar*, ſalt of *ſorrel*, &c. and to ſeveral other eſſential ſalts, which ſeem to be intermediate betwixt the ſtate of pure acids and of neutral ſalts.

SALTS *with* BASES ALKALINE, EARTHY *and* METALLIC.

By theſe general denominations the ſeveral neutral ſalts are diſtinguiſhed according to the nature of the baſis, or ſubſtance with which the acid is combined. *See the above enumeration of ſalts. See alſo the article* Neutral Salts.

SALT ALEMBROTH.

This is a ſaline matter, compoſed of *corroſive ſublimate* and of *ſal ammoniac*, mixed in equal parts, or in other different proportions, which the ancient chemiſts, eſpecially the alchemiſts, have much employed as a powerful ſolvent of metals, and even of gold. We are certain that corroſive ſublimate and ſal ammoniac act powerfully one upon another, and combine together without being decompoſed, from which is formed a ſaline compound of a ſingular nature, capable of acting very effectually upon metallic ſubſtances. But the alchemiſts, who made ſo much uſe of this famous ſolvent, were far from underſtanding clearly the operations in which they employed it. As alchemiſts loved pompous names, they called this compound *ſalt of art*, *ſalt of wiſdom*, *ſalt of ſcience*.

ALKALINE SALTS.

This name is frequently given to saline alkaline substances, as *fixed alkalis*, *vegetable* and *mineral*, *volatile alkali*. *See these words*.

SALT *of* AMBER, *or* VOLATILE SALT *of* AMBER.

This is a saline, oily, concrete matter, obtained by sublimation, or even by crystallization, from amber. It is a kind of essential salt, which forms shining needle-like crystals, has the smell of rectified oil of amber, and is soluble in spirit of wine. It is used only medicinally, as an antispasmodic, with the same effect as the spirit and rectified oil of amber. *See* BITUMENS *and* SALTS (ESSENTIAL).

AMMONIACAL SALTS.

By this name are distinguished all neutral salts composed of any acid saturated with volatile alkali. *See* AMMONIACAL SALTS; *and* SALTS (NEUTRAL).

ARSENICAL SALTS.

See SALT (NEUTRAL ARSENICAL).

COMMON SALT.

Common salt is a neutral perfect salt, composed of a peculiar acid and a peculiar alkali, which are called *marine acid*, and *marine* or *mineral alkali*.

This salt, which is produced by nature, is more abundantly and universally diffused than any other. Immense mines or quarries of it are found within the earth, and it is then called *sal gem* or *fossile salt*. The waters of all the sea, and many subterranean and mineral waters, contain it. From every vegetable or animal chemists can extract it.

The taste of common salt is agreeable and moderately strong. It is crystallizable, and is one of those the figure of whose crystals is most regular, most determinate, and least variable. The crystals of this salt are perfect, or nearly perfect cubes; for the hollow pyramids obtained in certain evaporations of salt waters are nothing but a heap of cubical crystals, arranged in this manner near each other, by means of evaporation.

Common salt is moderately soluble in water. Four parts of water are required to dissolve one part of salt; and hot or boiling water dissolves no more of it than cold water. For which reason it is only obtainable from sea-water

water, and other waters impregnated with it, by a continued evaporation. *See* CRYSTALLIZATION.

Although common ſalt be very cryſtallizable, and exactly neutral, it very readily becomes moiſt when expoſed to humid air. It muſt be preſerved in very dry places.

This ſalt is ſuſceptible of contracting a certain union with *common ſalt with calcareous baſis*; for which reaſon all the ſalt obtained either from ſea-water or ſalt fountains always contains a certain quantity of this ſalt with earthy baſis. Thus, if any common ſalt be diſſolved in very pure water, and fixed alkali be added to this ſolution, we ſoon ſee the white earth of the ſalt with earthy baſis which is precipitated. As therefore cryſtallization ſeems inſufficient for the purification of common ſalt from the ſalt with earthy baſis, when we would obtain a very pure common ſalt, as is neceſſary for ſome delicate operations, we muſt diſſolve it in water, filtrate it, and add to it a ſolution of cryſtals of ſoda, or marine alkali, till no more white cloud is formed by the addition; then filtrate again the liquor, and evaporate. By this method we ſhall obtain a common ſalt perfectly pure. (*q*)

Common ſalt expoſed to the action of fire, crackles and decrepitates pretty ſtrongly, when heated to a certain degree, eſpecially if it be heated haſtily. Its cryſtals burſt into ſmall pieces during this decrepitation. This effect is produced by the water of the cryſtallization of the ſalt, which being confined by the parts of the ſalt, and at the ſame time reduced into vapors by the action of fire, burſts the parts of the ſalt, and is diſſipated. Many chemiſts conſider this decrepitation of common ſalt as a property peculiar to it, and by which it may be known; but vitriolated tartar, nitre of lead, and probably many other ſalts, are ſuſceptible of a ſimilar decrepitation.

If ſalt be expoſed to a red-heat after this decrepitation, it fuſes; and when afterwards cooled, it fixes in form of a white and almoſt opake maſs; but excepting that it has loſt the water of its cryſtallization, it is the ſame as before this expoſure to fire.

Several chemiſts, having obſerved that when common ſalt is heated in a retort, a little marine acid exhales from it while it contains any moiſture, and that by adding more moiſture, more acid may be thus obtained, have believed that, by means of water, all its acid may be expelled from it. But they have been deceived; for this ſmall quantity of acid obtained by repeated humectations and diſtillations proceeded only from the common ſalt with earthy baſis, which, we have obſerved, is always mixed with common ſalt. From this

(*q*) Sea-water contains diſſolved in it not only ſea-ſalt, or a combination of marine acid with mineral alkali, but alſo other ſalts, eſpecially combinations of marine and vitriolic acids with the earth called magneſia, which is not calcareous. *See* MAGNESIA, *and the Note ſubjoined.* Some of theſe ſalts, with baſis of magneſia, are cryſtallized along with the ſea-ſalt by the evaporation of the ſea-water, and part of them remains in the reſiduous liquor called the mother-water. Some portion of true calcareous earth, diſſolved by marine and vitriolic acids, is ſaid alſo to be contained in ſea-water; but the quantity of this is very ſmall in compariſon of the quantity of magneſia; to the precipitation of which, therefore, the cloud or turbidappearance given to ſea-water or to a ſolution of common ſalt in water, is chiefly owing.

earthy ſalt a portion of acid may actually be obtained by this method; but Mr. Beaumé has found, that no acid can be thus expelled from common ſalt perfectly purified in the above-mentioned manner.

This ſalt is abſolutely unalterable by fire, even when i has been heated ſtrongly, together with inflammable matters. The unalterable property of common ſalt by fire proceeds from the ſmall diſpoſition which its acid has to combine with phlogiſton. This truth has been demonſtrated by the experiments of Mr. Duhamel and of Mr. Margraaf.

Although this ſalt be fixed in the fire to a certain degree, yet when it is expoſed to a violent fire with free acceſs of air, it exhales in vapors, and attaches itſelf in white flowers to bodies which it finds leſs hot than itſelf. We have examples of this effect in certain fuſions of ores, where common ſalt is added; and in glaſs-houſe furnaces, where this ſalt, of which a certain quantity is contained in ſoda and potaſh, and which cannot enter into vitrification, attaches itſelf to the ſides of the openings or holes.

We know no other acid but vitriolic and nitrous acids, and ſedative ſalt, which can decompoſe common ſalt by diſengaging its acid: for arſenic, which ſo eaſily and effectually decompoſes nitre, cannot act upon this ſalt; a phenomenon, the cauſe of which deſerves to be examined, and which is certainly connected with an important theory.

Common ſalt is of all ſaline ſubſtances the moſt neceſſary, and extenſively uſeful. Beſides the particular uſes of its acid and alkali in many chemical operations and in arts; beſides its great utility in the fuſion of glaſs, which it whitens and purifies, although it does not enter, and perhaps becauſe it does not enter into their combination, as Mr. d'Antic has ſhewn; and from the property it has of facilitating the fuſion and precipitation of the metallic parts of minerals in eſſays, and of covering them perfectly; beſides theſe, I ſay, its great uſe in aliments, the taſte of which it improves by its agreeable piquancy, when mixed in proper quantity, is univerſally known. But this is not the only advantage; for it retards and prevents the putrefaction of almoſt all our aliments, without producing any ſuch change upon them, even when preſerved a long time by means of it, as to render them unfit for the purpoſe of nouriſhment. All other ſaline matters may indeed preſerve from putrefaction, as common ſalt does, and ſome of them even more effectually: but we do not know any other, the taſte of which renders it capable of being ſubſtituted to common ſalt for this purpoſe.

A very remarkable circumſtance in the antiſeptic property of common ſalt, and of ſome other ſalts, is, that this property varies ſurpriſingly according to the proportions in which the ſalt is employed: for this ſalt, mixed with animal matters in a large proportion, preſerves them from putrefaction, which it accelerates conſiderably when a ſmall quantity only of it is employed. This ſingular fact is proved by the experiments of Meſſrs. Pringle and Macbride, and particularly by thoſe of the accurate and intelligent author of *an Eſſay towards a Hiſtory of Putrefaction*, Mr. Gardane, Phyſician of the Faculty of Paris, who, having convinced himſelf of this fact by his own experiments, mentioned it in a very good theſis, and has drawn from it a concluſion which ſeems to me very juſt, namely, that ſmall quantities of common ſalt, ſuch as thoſe taken with aliments, facilitate digeſtion, which he conſiders as a beginning putrefaction.

putrefaction. If this opinion be as true as it is probable and consistent with the principles of chemistry, and of the animal economy, then common salt is not only agreeable and useful, but also salutary, at least to all constitutions in which the digestion is too remote from putrefaction, as in those which are properly called *crudities*: for we cannot but agree, that different temperaments differ much in this respect. *See the articles* ACID (MARINE), ALKALI (MINERAL), CRYSTALLIZATION, WATER (SEA), WATER *of* SALT FOUNTAINS, SALTS, *and* SALTS (NEUTRAL).

CRYSTALLIZABLE SALTS.

By this name we distinguish all saline matters susceptible of crystallization. It is contrary to that of *fluor salts*, by which are distinguished saline substances that cannot be obtained in a crystallized concrete form, such as nitrous and marine acids, volatile alkali altered by quicklime, and some others. We have nevertheless reason to believe, that, rigorously speaking, every saline substance is essentially susceptible of crystallization, and that in this respect they only differ in the degree of facility with which they may be crystallized; for we are certain that many very deliquescent salts, the crystallization of which has not, that I know of, been ever observed, such as *common salt with calcareous basis*, may nevertheless assume solid regular forms by the cooling of their solutions when very much concentrated. Mr. Beaumé has observed the crystallization of this and several similar salts. *See* CRYSTALLISATION, DELIQUESCENCE, SALT, *and* SALTS (NEUTRAL).

SALTS *of* CENTAURY, *of* WORMWOOD, *of* SORREL, &c.

The name of *salt*, added to the proper name of some substance, is applied to very different matters. It is given, for example, to all the fixed alkalis obtained from the ashes of vegetable matters. Salts of wormwood, centaury, &c. are saline matters obtained by lixiviating the ashes of these plants: but these names are improper in several respects; for if we apply them to the fixed alkalis of plants, as they do not differ from each other, it is useless to distinguish them by the name of the plant from which they are obtained; and even when they are prepared in Tachenius's method, although they differ a little, yet their character of fixed alkali is so predominant, that no name ought to be given to them but what has a relation to that character. Accordingly, the names, *salt of tartar*, *salt of soda*, which are frequently given to the alkalis of these substances, are for the same reason very improper. They ought to be called *alkali of tartar* and *alkali of soda*.

Certain concrete acids, as the essential salt of sorrel, tartar, &c. are also simply called *salt of sorrel*, &c. This is also faulty, because these names do not denote the nature of the saline matters, and may be the occasion of confounding them with other salts of a very different nature. They ought to be named *essential salts*, or rather *concrete acids of sorrel, of tartar*, &c.

The names *salts of coral, of pearls, of crabs eyes*, are not more accurate, unless we add the epithet *acetous*, as *acetous salt of coral*, &c. for these substances may be combined, and may form salts with any other acid, as well as with vinegar.

Let us now judge if the names, *salt of quinquina, of sena, of onions*, &c. given to the dry extracts of these matters made in the manner of the Count de la Garaye, are not entirely improper. *See the preceding enumeration of salts.*

SALT *of* COLCOTHAR.

This is a white saline matter, obtained by lixiviating colcothar. This matter is not much used, and has not been much examined. It is probably some *selenitic* or *aluminous* substance, which is mixed with the vitriol, and which was contained in the pyrites from which the vitriol was extracted.

SAL DE DUOBUS.

It is a neutral salt, formed by saturating vitriolic acid with the alkali of nitre. *See* TARTAR (VITRIOLATED).

DELIQUESCENT SALTS.

Thus are named all saline matters which may be obtained by crystallization or drying in a concrete form, but which, when exposed to air, imbibe its moisture, and lose their concrete crystallized form, deliquiating into a liquor by means of this moisture. *See* DELIQUESCENCE.

SALTS *of* ENGLAND, *of* EPSOM, *of* SEDLITZ.

Some saline substances have been denominated from the countries where they have been first discovered. Thus a very rectified concrete volatile alkali, obtained from silk, is called *salt of England*; and even some druggists give this name to the concrete volatile alkali obtained from sal ammoniac.

In a similar manner, the name of Epsom salt is given to a badly crystallized, bitter Glauber's salt, which easily becomes moist, because it is mixed with common salt, and common salt with calcareous basis. It was first obtained from a salt well at Epsom near London. This name has been since given to a similar Glauber's salt obtained from salt marshes in France, and also to a true and pure Glauber's salt obtained from the *schlot* of the salt-works of Lorraine and Franche-compté, the crystallization of which they disturb purposely to prevent it from resembling entirely the pure salt of Glauber.

Salt of Sedlitz is also a Glauber's salt under another name; and perhaps the same may be said of many other salts denominated from places.

ESSSEN-

ESSENTIAL SALTS.

This name is given to all concrete saline matters which preserve the smell, taste, and all other principal qualities of bodies from which they were obtained, which bodies are only vegetable and animal. The usual method of preparing them is by evaporating, to almost the consistence of a syrup, the liquors containing the essential salt, namely, the expressed and depurated juices and strong decoctions, and by keeping them in a cold place. From many of these liquors, saline matters or crystals are deposited upon the sides of the containing vessels after a considerable time, and after they have undergone a kind of fermentation. These crystals, which are always very red, may be purified by dissolving them in water, filtrating, evaporating, and crystallizing.

We may observe, that the salts thus obtained from animal and vegetable matters are sometimes nothing but vitriolated tartar, Glauber's salt, nitre, common salt, and other such neutral salts, which ought not to be considered as the essential salts of the substances from which they are extracted.

These mineral salts are extraneous to the vegetables and animals from which they are obtained. They are not parts of those substances, nor are combined with them; and when they are purified from the extractive matter with which they are at first only mixed and covered over, they have then nothing vegetable or animal. These salts are introduced into vegetables and animals along with aliments, are mixed in their liquors and circulate in their vessels, but receive no alteration, nor contract any true union with the proximate principles of animals and vegetables, because they are naturally incapable of such union.

The proof of this truth is, that they are always obtained from vegetables and animals in the same state in which they were introduced, and that their quantity in these substances is altogether unconstant and variable, without any real difference being produced in the vegetables or animals by this variation of the quantity of these salts. Certain plants, as the *parietaria*, but still more the *corona solis*, have the property of imbibing so much nitre, that, when they grow in nitrous soils, they are almost filled with this salt. I have seen the dried pith of corona solis so full of crystallized nitre, that when shook over a paper, a considerable quantity of good deflagrating nitre might be collected. But we know also that this plant, when cultivated in a less nitrous soil, does not contain nearly the same quantity of nitre, although it be otherwise in good condition. These mineral salts therefore must not be considered as the essential salts of plants or animals; and only those salts are to be considered as such, in the combination of which we find oily parts, which cannot be separated from them, unless the salt be decomposed.

In the second place we shall observe, concerning salts truly called essential, that but very few of them are yet known, and most of these but very imperfectly. Of all these essential salts the best known is tartar, the properties of which may be seen under the article TARTAR. The druggists have a very white concrete salt, well crystallized, and soluble in water, which they call *salt of sorrel*. We may indeed obtain from the juice of sorrel, by the above-mentioned process, an essential acid concrete salt, but much more earthy and less acid

that

than the salt above-mentioned. Besides, Mr. Beaumé, who has made some inquiries into this matter, affirms, that a true salt of sorrel could not be procured at the price of the salt which is commonly sold under that name, the quantity of salt obtainable from sorrel being very small. The salt above-mentioned is brought from Germany, is much more acid and more soluble in water than cream of tartar; it acts upon all substances soluble by acids; but the neutral salts thence formed have not been examined.

Flowers of benjamin, *volatile salt of amber*, and other saline matters of the same kind, seem to belong to this class of essential salts; but they are little known. Essential salts may be considered as a new subject of inquiry.

FIXED SALTS.

Many chemists give this name to the salts obtained from the ashes of plants, which not having been dissipated by fire, ought to be considered as fixed, in comparison of the other saline matters of these plants, which evaporate during their deflagration.

As the saline substances remaining in the ashes of vegetables are entirely or chiefly alkaline, the name of *fixed salt* has become synonimous with that of *fixed alkali*. But other saline substances, as most neutral salts, which have not bases of volatile alkali, are nearly as fixed as fixed alkali.

The fixity of any saline matter is not perfect; since any of them by a long-continued violent fire may be altogether evaporated. A proof of this we find in glass-houses. A part of the fixed alkali, of the common salt, of Glauber's salt, of vitriolated tartar, and other equally fixed salts, contained in the ashes used in the composition of glass, are perpetually exhaling, during the fusion of glass, in a vapor which may be seen above the pots; and this vapor forms saline incrustations round the openings and other least hot places of the furnace. Accordingly, the quantity of salt of glass which covers the surface of the melted glass is continually diminishing. I have had occasion to take from a vitrifying furnace, at different times, eighty crucibles, containing all the same composition for crystal-glass, of which soda and pot-ash made parts. The crucibles first taken out were covered with a crust of salt of glass more than two lines thick; those taken out 18 or 20 hours afterwards had only a very thin stratum of glass-gall; and, lastly, the crucibles which remained 72 hours in the fire, had no salt, or only a very small quantity, upon the middle of the surface of glass.

Hence we ought to conclude that the quality of fixity ascribed to some salts is only relative. We consider those as fixed which sustain a red heat during several hours, without any sensible diminution. Salts which by a red heat are reduced into vapors and sublimed, are called *semi volatile*, as the ammoniacal salts, and corrosive sublimate; and lastly, salts which are dissipated without heat, or with very little heat, as the volatile acids and alkalis, are called *volatile salts*.

FLUOR

FLUOR SALTS.

This name is given to all saline substances which cannot by any method be rendered solid; such are nitrous and marine acids, volatile alkali altered by quicklime, and some others. This quality depends on their volatility, and on the affinity which they have with water superabundant to their saline essence. In this latter point they resemble deliquescent salts, and they may even be considered as salts perpetually, and unsurmountably deliquescent. But they differ from salts that are only deliquescent, in this circumstance, that these latter are much less volatile than the fluor salts, and can support a heat sufficient to deprive them of all their superabundant water, and to reduce them to a concrete form. *See* DELIQUESCENCE *and* SALT.

FUSIBLE SALT *of* URINE.

This salt, called also *native* or *essential salt of urine*, *phosphoric salt*, *microcosmic salt*, is a neutral salt composed of an acid named *phosphoric*, saturated with an alkali fixed or volatile; for both these kind of alkalis seem to be contained in urine.

To obtain this salt, urine fresh or putrid is to be evaporated to the consistence of a syrup, slowly or quickly. This urine, which is then very red, or brown, is to be put in a cold place. The fusible salt crystallizes on the sides of the vessel. When the salt ceases to form itself on the vessel, the liquor is to be decanted, and again evaporated, that still more crystals may be obtained by the same method. These crystals are to be collected, which are very dirty and brown. They may be purified by dissolving in pure water, filtrating, evaporating, and crystallizing, according to the general method. These operations ought to be repeated when the salt is required to be very white and pure. Thus they are disengaged not only from the extractive part of the urine which discolors them, but also from a portion of common salt which may be mixed with them, particularly when the urine has been much evaporated.

This salt is very susceptible of crystallization, and is one of those which are more apt to crystallize by cold, than by evaporation.

If this salt be exposed to the action of fire in close vessels, a very pungent volatile alkali is expelled from it, which Mr. Schlosser has observed to be always fluor, like that which has been altered by quicklime. This chemist affirms even that if concrete volatile alkali be combined with the fusible salt of urine, and separated from this salt by distillation, it will be in a fluor state.

The acid of this salt is fixed, and remains at the bottom of the vessels, melted to a vitreous matter, if the heat has been sufficient for that purpose. This is the acid which produces the phosphorus of Kunckel, by its combination with the inflammable principle, and which gives the characteristic properties to the fusible salt of urine. *See the properties of this acid under the article* PHOSPHORUS *of* KUNCKEL.

If this fusible salt be mixed with the other fusible salt with basis of fixed alkali, as this latter salt cannot be decomposed merely by distillation, nor even by means of phlogiston, phosphorus is therefore chiefly produced from the former, or the ammoniacal fusible salt. *See* PHOSPHORUS *and* URINE.

FOSSIL SALTS.

Thus are called all the salts obtained ready formed within the earth; but more particularly common salt, which is coagulated in large masses within the earth, more frequently called *sal gem*.

SAL GEM.

Sal gem is fossil common salt, or which is found within the earth in large masses: It has some transparency, by which it resembles crystal a little; and hence it has been called sal gem. The most considerable mines of this salt are in Poland. Very curious and interesting particulars concerning these mines may be seen in a Memoir of Mr. Guettard, in the Memoirs of the Academy of Sciences.

SALT *of* GLASS.

This matter, called also *glass-gall*, is a kind of saline scum or mass, found in glass-house pots upon the surface of the melted glass. It consists of neutral salts, as common salt, vitriolated tartar, and others which are contained in the soda and potash employed in the composition of glass, and which not being themselves susceptible of vitrification, are separated from the glass during the fusion, and are collected together upon its surface, because they are specifically lighter. Hence we see, that as all the soda and potash employed for the composition of glass contain more or less of these extraneous neutral salts, the salt of glass must vary according to the saline substances employed. For the same reason no salt of glass is found where only pure and vitrifiable salts, as purified alkalis, nitre, borax, &c. are employed. *See* VITRIFICATION.

GLAUBER's SALT.

The salt thus named, from the chemist who discovered it, is a neutral salt, composed of vitriolic acid saturated with marine alkali.

Glauber discovered this salt, while he was decomposing common salt by means of vitriolic acid, to obtain the smoking marine acid by distillation. The residuum of this distillation he found to be a saline mass, not crystallized, which he dissolved in water, and obtained, by evaporation and cold, transparent crystals. Glauber, surprised with the appearance and properties of these crystals, gave them

them the name of *sal mirabile*, by which they are ſtill known, but more generally by that of *Glauber's* ſalt.

This ſalt, although compoſed of vitriolic acid and a fixed alkali, as vitriolated tartar is, yet it differs from this latter ſalt in many reſpects, which differences are to be attributed to the difference of the alkaline baſes, one being the vegetable fixed alkali, and the other the marine fixed alkali. The taſte of Glauber's ſalt is ſaltiſh but diſagreable and bitter. It is one of the ſalts which form the fineſt cryſtals. When large quantities of this ſalt are cryſtallized, and with due attention, large, oblong, columnar cryſtals are formed, the ſurfaces of which are ſtriated longitudinally, like thoſe of nitre.

The cryſtals of this ſalt are as tranſparent as ice, but when expoſed to a dry air they loſe their tranſparency by the evaporation of the water of their cryſtallization. Their ſurface, and afterwards the whole of the ſaline maſs, is reduced by the diſſipation of this water to a white ſaline powder. This change alſo happens to the cryſtals of marine alkali, to which probably this property of Glauber's ſalt muſt be attributed.

The quantity of water which enters into the cryſtallization of Glauber's ſalt is very conſiderable, and amounts to nearly one half of its weight. To this large quantity of water is probably owing the ſize and tranſparency of the cryſtals: For it ſeems to be a general rule, that the more water is contained in any ſalt, the more large and tranſparent its cryſtals are. From this ſame abundance of water, Glauber's ſalt liquefies with a heat quickly applied, till all the water be evaporated; and then it becomes dry and ſolid, and requires greater degree of heat to fuſe it.

This ſalt, although very ſoluble, even in cold water, is one of thoſe which may be diſſolved in a leſs quantity of boiling than of cold water. Hot water diſſolves nearly an equal weight of it. From this property we may know, that the cryſtallization of Glauber's ſalt is beſt procured by the cooling of a ſufficiently evaporated ſolution. Accordingly, a ſure method of obtaining the fineſt cryſtals of ſalt of Glauber is, to evaporate the water, in which it is diſſolved, till we find by taking out and trying a ſmall quantity of the ſolution while evaporating, that cryſtals are pretty quickly formed by cooling. It is then to be poured into flat and ſhallow veſſels, and cooled ſlowly. The larger the quantity of liquor is operated upon at a time, the larger will the cryſtals be; ſo that they may be obtained ſeveral feet long, and proportionably thick. Theſe cryſtals are placed horizontally upon each other, and the cryſtallization ought therefore to be performed in wide veſſels. *See* CRYSTALLIZATION.

Glauber's ſalt cannot be directly decompoſed but by means of phlogiſton only: For the decompoſitions made of it by metallic ſolutions are by means of a double affinity: and the decompoſition which may be effected by the nitrous acid alone, upon Glauber's ſalt and vitriolated tartar, as Mr. Beaumé diſcovered, is alſo cauſed by phlogiſton. (*r*)

(*r*) The ſingular decompoſition of vitriolated tartar, and of Glauber's ſalt, by means of nitrous acid, as mentioned by Mr. Beaumé, does not ſeem to be cauſed by the phlogiſton of the nitrous acid, as the author of the Dictionary believes; for Mr. Margraaf affirms, that theſe neutral ſalts, and alſo that nitre, may be decompoſed in a ſimilar manner by marine acid.

Glauber's salt is used only in Medicine. In small doses, as from one to two gros, it is resolvent and aperitive, and as such is added to ptisans and apozems. It is also employed as an attenuant and corrective in the same dose in purgative potions; and it is itself a good and mild purgative, as all the neutral salts are, the basis of which are fixed alkali: The dose of this salt as a purgative is from an ounce to an ounce and a half.

To prepare Glauber's salt, we need not combine the pure disengaged vitriolic acid with the alkali of soda, nor decompose common salt by vitriolic acid, as Glauber did, unless we desire to obtain at the same time the marine acid. Nature furnishes a large quantity of this salt ready formed. A considerable quantity of it is contained in mineral waters, and perhaps all waters which contain common salt contain also some Glauber's salt. *(s)* The salt wells of Lorraine, of Franche-compté, of Epsom, contain much of it, and from these it may be easily obtained by crystallization. Further, from all vitriolic salts with earthy or metallic bases, as selenites, alums, vitriols, Glauber's salt may be obtained by decomposing them with soda. Lastly, by burning sulphur with common salt or soda, this salt may be formed. If it were much wanted, it might be easily and cheaply made by these processes. *See the articles* ACID (VITRIOLIC), ALKALI (MARINE), CRYSTALLIZATION, WATER *of the* SEA, *and of* SALT FOUNTAINS, SALT, *and* NEUTRAL SALTS.

S A L T *of* L E A D.

Thus is commonly called the neutral salt composed of the acid of vinegar saturated with lead. As this salt has a sweet and saccharine taste, it is called *sugar of lead.*

To make this acetous salt, ceruss, which is lead half dissolved, and corroded by vinegar, is to be entirely dissolved in distilled vinegar by means of heat in a sand-bath; the liquor, when perfectly saturated, is to be evaporated, and crystallized by cooling, and many small needle-like crystals will be formed in it, which are to be well drained.

This salt is not much used in medicine. It is used only externally, because the lead is pernicious. It is employed in some arts, and especially in dyeing, to heighten the red color of madder. *See* CERUSS, LEAD, *and* VINEGAR.

(s) Glauber's salt, that is, a salt formed by vitriolic acid combined with mineral alkali, is contained in sea-water and in many mineral waters. But the *sal catharticus amarus* of the London Dispensatory, extracted from the bitter liquor remaining after crystallization of sea-salt in sea-water, and the *salt of Epsom,* and of most purging waters, tho' very similar in appearance to the true Glauber's salt, with which it is frequently confounded, is found to be composed of vitriolic acid united with the earth called magnesia. See *magnesia.* This salt consists of prismatic crystals like those of Glauber's salt; has a bitter taste; is soluble in less than an equal weight of water; when exposed to a moderate heat, it quickly liquefies, and loses the water of its crystalliz tion, which amounts to more than half its weight; and is changed by this calcination into a white powder, almost totally soluble in water, by addition of which, together with evaporation, it may be restored to its former crystallized state.

LIXIVIAL SALTS.

This is a general name given to all ſaline ſubſtances obtained by lixiviation of aſhes, but is particularly applied to fixed alkalis, becauſe the ſalts thus obtained from aſhes are altogether or moſtly alkaline. *See* ALKALI (FIXED).

NEUTRAL SALTS.

If this name be taken in its moſt extenſive ſenſe, it ought to be given to all the combinations of any acids with any alkaline, earthy, or metallic ſubſtances. Theſe are ſalts formed with baſis of fixed alkali, vegetable or marine; with baſis of volatile alkali, called ammoniacal ſalts; or with baſes of calcareous and argillaceous earths; and, laſtly, thoſe with baſes of metallic ſubſtances. *See the above enumeration of ſalts.*

The name *neutral*, given to theſe ſalts, relates to the reciprocal ſaturation of their acids and their baſes. This ſaturation ought to be ſuch, that the properties of the two principles of the neutral ſalt ſhould be neither thoſe of a pure acid, nor of its pure baſis, but mixed or intermediate; and from hence theſe ſalts have alſo been called *intermediate ſalts*, or *ſales medii.*

The moſt important conſideration concerning theſe ſalts, is the juſt ſaturation of their two component principles. A neutral ſalt ought to be conſidered as perfect in its kind, when its acid and baſis are each of them in the moſt perfect relative ſaturation; that is, when the acid and the baſis are united together in as large quantity and as intimately as they can be, each according to its nature. But we muſt remark upon this ſubject, that a neutral ſalt may be perfect in its kind, and exactly ſaturated in the ſenſe we have mentioned, altho' its principles be very far from being completely or abſolutely ſaturated; that is, altho' they have not exhauſted upon each other all their tendency to combine. In this reſpect the neutral ſalts differ much; and on this chiefly depend the eſſential differences evidently obſervable in the taſte, ſolubility, cryſtallization, deliqueſcence, facility of decompoſition, and action upon other ſubſtances, of theſe neutral ſalts.

From a circumſtantial examination only of the properties of neutral ſalts, we can acquire any knowledge concerning them; but we are far from having ſufficiently examined them: for beſides that many ſaline combinations are quite unknown, and have never been made, many things are yet undetermined even concerning thoſe ſalts which are beſt known. We need not therefore be ſurprized that we cannot yet eſtabliſh a good general theory concerning neutral ſalts. We ſhall here only mention ſome general principles which ſeem to reſult from what is already known, and which ſeem capable of leading us to further reſearches.

Firſt, the neutral ſalts, reſulting from the union of acids in general with fixed alkalis, are more abſolutely ſaturated than thoſe with baſis of volatile alkali, and theſe more than ſalts with baſis of earth, excepting ſelenites; and, laſtly, the ſalts with baſis of earth are more abſolutely ſaturated than ſalts with metallic baſes. In the firſt claſs of theſe ſalts, namely, thoſe with baſis of

fixed

fixed alkali, we find moſt of the ſalts which have the leaſt taſte, ſolubility, deliqueſcence, action upon other bodies, or facility of decompoſition, and the greateſt tendency to cryſtallization. On the contrary, in the laſt claſs, namely, the ſalts with metallic baſes, we find moſt of thoſe that are corroſive, moſt ſoluble, deliqueſcent, leaſt cryſtallizable, moſt active upon other ſubſtances, and moſt eaſily to be decompoſed. The two intermediate claſſes with baſes of volatile alkali, and of earth, are alſo intermediate with regard to theſe properties.

Secondly, as the ſeveral acids are more or leſs ſimple and powerful, they form with the ſubſtances to which they are capable of uniting, neutral ſalts, the abſolute ſaturation of which is more or leſs perfect, according to the nature of the acid. Neutral vitriolic ſalts are the firſt in this reſpect, then nitrous and marine ſalts, or marine and nitrous ſalts; for theſe acids do not differ much; and, laſtly, acetous and tartareous ſalts.

We ought to obſerve upon this ſubject of general conſiderations upon neutral ſalts, that we muſt not judge, from one or a few of their properties, concerning the degree of coheſion and of abſolute ſaturation of their principles, but from all their properties taken and compared together; becauſe poſſibly one of the principles of a ſalt may be abſolutely, or almoſt abſolutely, ſaturated, while the other principle may be far from this degree of ſaturation; and according as the acid or the baſe is moſt ſaturated, the properties of the neutral ſalt muſt vary conſiderably. For example; we ſhould be much miſtaken, if, upon conſidering that corroſive ſublimate is leſs ſoluble in water than common ſalt, and not at all deliqueſcent, as the latter ſalt is a little, we ſhould conclude, that the coheſion of the principles of corroſive ſublimate and their abſolute ſaturation are much ſtronger than in common ſalt. The corroſive quality of this ſalt, and its powerful action upon many bodies, which properties do not, or ſcarcely, exiſt in common ſalt, evidently prove the contrary. *See* SUBLIMATE (CORROSIVE).

We muſt alſo obſerve, that in many combinations of neutral ſalts, and particularly of thoſe with metallic baſes, ſome metals and the acids themſelves ſuffer, by the very act of combination, certain alterations which have great influence on the nature of the neutral metallic ſalt reſulting from their union: for inſtance; although lunar and mercurial nitre be cryſtallizable, and little, if at all, deliqueſcent, while the nitres with baſes of copper and of iron are very much ſo, we muſt not thence conclude, that iron and copper ſaturate the nitrous acid leſs than ſilver and mercury do; becauſe we are certain that this difference does only proceed from this circumſtance, that while the nitrous acid diſſolves copper and iron, it decompoſes them, and deprives them of much of their inflammable principle which is neceſſary to the connexion of metals with acids, while it does not produce the ſame effect ſo evidently upon ſilver and mercury. Accordingly, the ſalts, which reſult from the ſolution of copper and of iron by nitrous acid, ought not to be rigorouſly conſidered as combinations of theſe metals, but rather as combinations of their earth with this acid: for as nitrous acid quits ſilver and mercury to diſſolve copper and iron, probably if this ſolution could be made without loſs of the phlogiſton of theſe latter metals, they would more compleatly ſaturate this acid, and more firmly adhere to it, than the former metals.

Many

Many other considerations of this kind may be made concerning the different kinds of neutral salts; but the detail of them would engage us too long, besides that they will easily occur to those who would attentively reflect on this subject. We will however mention something concerning a discussion that has arisen lately betwixt some chemists relative to neutral salts.

Mr. Rouelle had advanced, in a Memoir of the Academy in 1754, that several of these salts may be in two different states; that is, they may be in a state of a perfect saturation, or, they may have an excess of acid. He cites for examples several combinations of metallic matters with acids, such as those of mercury with marine acid and with vitriolic acid, and that of bismuth with nitrous acid. Each of these metals may, according to him, form with the same acid two very different neutral salts, one of which has an excess of acid, and contains the largest possible quantity of acid; and the other is precisely saturated, and contains the smallest quantity possible of acid. This chemist cites also, as another instance of the same doctrine, the combination of a fixed alkali with an acid. It is that of the vegetable fixed alkali with vitriolic acid, forming consequently the neutral salt called *vitriolated tartar*. Mr. Beaumé has opposed this opinion in many Memoirs read at the Academy, and also in the Journal and Gazette of Medicine. He disputes the facts upon which Mr. Roulle establishes his theory. He maintains, that many of the saline metallic combinations cited by Mr. Rouelle as examples, and considered by him as neutral salts containing the least possible quantity of acid, are nothing less than salts; but metals, deprived of all acid, when the acid which adheres superficially to the precipitated metal is sufficiently washed from it; and he thinks that Mr. Rouelle has been mistaken, from not having sufficiently washed these metallic precipitates, which he considered as salts. Mr. Beaumé proves his opinion, by washing with a very large quantity of distilled and boiling water turbith mineral and mercurius vitæ; which precipitates he, by this method, deprived of every particle of acid.

With respect to the vitriolated tartar, the process by which Mr. Rouelle gives it an excess of acid is, by distilling in a retort two ounces of pure vitriolic acid upon this salt, till the salt is dry, and even till the retort has been kept red-hot during an hour. Mr. Rouelle observes, that when vitriolic acid is poured upon this salt, a considerable heat is excited, even when the salt has been deprived of the water of its crystallization by drying; and thence concludes, that the acid acts upon and combines with the salt. The saline mass remaining after the distillation melts, and weighs, as Mr. Rouelle has observed, five ounces and one gros. This, according to him, is vitriolated tartar with excess of acid. He affirms also, that in this salt, as in all those which are susceptible of receiving excess of acid, there is a point of saturation of this excess of acid, and this point is marked in the present operation by the ceasing of white vapors which rise during the distillation. This vitriolated tartar with excess of acid has really an acid taste; it attracts the moisture of the air, resolves in a liquor, like the deliquescent salts, reddens the tinctures of violets and of turnsol, effervesces with fixed and volatile alkalis, and, lastly, in crystallizing, remains acid.

Mr. Beaumé acknowledges almost all these facts; but he denies that we ought thence to conclude, that vitriolated tartar really contains an excess of combined acid. He supports his opinion upon the following facts and reasons:

Vitriolic

Vitriolic acid distilled from pure sand, in the same manner as Mr. Rouelle distilled that acid from vitriolated tartar, adheres to it in the same manner, although we are certain that it does not act upon sand. In this therefore, and in many cases, it is only an adhesion of juxta-position, which vitriolic acid is capable of contracting with any body from the degree of fixity which it has, especially when perfectly concentrated.

In the second place, the vitriolic acid, with which Mr. Beaumé affirms the vitriolated tartar is only superficially covered, by Mr. Rouelle's process, is so far from being truly combined, that it may be entirely separated without fire, or any intermediate substances, by means purely mechanical: for by draining this salt very carefully upon brown paper, or even upon clean sand, a vitriolated tartar perfectly neutral may be obtained, which preserves the water of its crystallization, and consequently the form and solidity of its crystals, and which no longer contains any vestige of an acid. From these experiments Mr. Beaumé concludes, that this excess of acid in vitriolated tartar is not real, and is, like the unwashed metallic precipitates, mistaken for salts with the least possible quantity of acid, one of those deceitful appearances against which we cannot too much guard. Mr. Beaumé generalises his proposition concerning the excess of acid of vitriolated tartar, and affirms, that no neutral salt with basis of fixed alkali either has an excess of combined acid, or of combined alkali, although it be crystallized in an acid or an alkaline liquor; and that the acid or alkali, with which these salts are mixed, when crystallized in such liquors, is only interposed betwixt their parts, and may always be carefully separated from them solely by the mechanical method of imbibition.

We shall not enter more particularly into these subjects, which perhaps will hereafter be further illustrated. We shall only observe, that if we were to examine these matters as well as they deserve, it seems essential to distinguish first metallic salts from all others; for the greater or less degree of concentration of acids seems indifferent, with regard to the saline combinations which result from the union of these acids with earths and alkalis both fixed and volatile; that is to say, the same quantity of acid remains united with the earths or alkalis, whether the acid employed be concentrated or diluted with water: but metals, especially some certain metals, cannot be combined, or remain combined with acids, in the greatest possible quantity, unless the acid employed be in a proper degree of concentration; so that the same quantity of the same acid, which, when sufficiently concentrated, is capable of remaining united with a certain quantity of metal, can dissolve only a much less quantity of the same metal, if this quantity of acid be diluted with a larger quantity of water.

This singular phenomenon of metals relative to acids can be only attributed to the inflammable principle which enters into their composition. Metals in general adhere only to acids by this principle, and not by their earthy principle, or at least much more by the former than by the latter: but on the other side, the union of water with any body is an obstacle to the combination of that body with the inflammable principle. A quantity of acid therefore, diluted with water, cannot be united but with a less quantity of metal than the same quantity of acid when concentrated. This seems to be naturally deduced from the fundamental principles of chemistry.

In

In the ſecond place, we may remark, that after having diſtinguiſhed metallic ſalts from all others, we ought alſo to diſtinguiſh the combinations of mercury and marine acid, and even the corneous metals, from all other metallic ſalts. Theſe ſalts make a diſtinct claſs, and have a peculiar character. *See upon this ſubject the article* SUBLIMATE (CORROSIVE).

Notwithſtanding the diſtinctions we have ſhewn between the different kinds of neutral ſalts, we are far from believing that they can be methodically diſtributed, from conſidering any of their common properties, or claſſed, as plants have been by botaniſts; becauſe each of them has ſo many peculiar, and, at the ſame time, very eſſential, properties, that the ſalts in the ſame claſs would often differ more from each other in their peculiar properties than they would be ſimilar in their common property by which the claſs is characteriſed. A proof of this truth may be ſeen in a Memoir inſerted in the Collection of the Academy for the year 1744, in which Mr. Rouelle has undertaken to claſs neutral ſalts according to their cryſtallization: for we find very different ſalts ranged not only in the ſame ſection, but alſo under the ſame genus, as, for inſtance, *ſal ammoniac*, and the *combination of lead with marine acid.* We do not mean to depreciate Mr. Rouelle's attempt upon this ſubject, or thoſe of others in the ſame way, as we are convinced, that however unſucceſsful theſe may be in their particular object, they muſt encreaſe our knowledge by the many experiments and obſervations which they require, and by the compariſons and new views they occaſion. We need only to read the above Memoir of Mr. Rouelle to be convinced of this

Neutral ſalts have many uſes in chemiſtry, arts, and medicine; but as theſe uſes depend upon the peculiar nature of each of them, we refer to the particular articles; and here we ſhall only ſay a little concerning their medicinal virtues.

We may obſerve, that theſe ſalts are antiſeptic when mixed in a proper doſe, that is, in a large doſe, with ſubſtances capable of putrefaction. Each of them reſiſts all kinds of fermentation more or leſs effectually: but the moſt exact experiments that have been made on this ſubject by Sir John Pringle, by the author of the Eſſay on Putrefaction, and by Mr. Gardane, phyſician at Paris, prove that theſe neutral ſalts, the principles of which are firmly connected, as all thoſe with baſis of fixed alkali, particularly common ſalt, rather accelerate than retard putrefaction. We find, from the experiments of the author of the Eſſay on Putrefaction, that the moſt powerful antiſeptics among the neutral ſalts are thoſe which are moſt aſtringent, as the neutral ſalts with metallic baſes.

All neutral ſalts with baſis of fixed alkali taken internally in the doſe of an ounce or more, produce in general a very mild purgative effect; and in ſmall doſes, as of one or two gros, they are only aperitive.

Ammoniacal ſalts are given in ſmall doſes only. They are exciting, dividing, and antiſcorbutic. The common ſal ammoniac is the only ammoniacal ſalt now uſed.

Moſt of the ſalts with baſes of calcareous earth are alſo conſidered as aperitive and dividing: but theſe ſalts differ much according to the nature of their acids. Thus ſelenitic ſalts are very different in their effects from nitrous and marine ſalts with calcareous baſes. Of thoſe ſalts, only the acetous, ſuch as the ſalts of coral, pearls, &c. are employed, and theſe but very little in France.

All the ſalts with metallic baſes are corroſive, eſpecially thoſe containing mineral acids. Accordingly, they are not internally employed in medicine, excepting ſome of thoſe with baſes of mercury, iron, regulus of antimony. *See the articles* IRON, MERCURY, REGULUS *of* ANTIMONY, *and* TARTAR (EMETIC).

NEUTRAL ARSENICAL SALT.

This ſalt is a combination of arſenic with fixed alkali to the point of ſaturation. Mr. Macquer firſt diſcovered this combination, and began an account of its properties in the Memoirs of the Academy for the years 1746 and 1748. His method of making this ſalt is, by mixing together equal parts of very white cryſtalline arſenic and purified nitre, and by diſtilling this mixture in a retort with a graduated heat in the uſual manner, till the retort is red-hot, and no more vapors of nitrous acid ariſe. In the retort a ſaline maſs remains, white, compact, and fixed; from which, after ſolution in hot water, filtration, evaporation, and cryſtallization, may be obtained beautiful, quadrangular, priſmatic cryſtals, terminated at each end by a quadrangular pyramid, the ſides of which correſpond with thoſe of the priſm.

Arſenic is known to have the property of decompoſing nitre, and of very eaſily diſengaging its acid; but, at the ſame time, it combines with the alkali of the ſalt, and ſaturates it preciſely as an acid would do; ſo that the new ſalt which reſults from this operation when well made, is exactly neutral, and gives no marks of an alkaline quality. It is infinitely more ſoluble in water than pure arſenic, and diſſolves in a leſs quantity of hot than of cold water.

This ſalt is eaſily fuſible by fire, and remains fuſed and tranſparent like glaſs, without being alkaliſed, if it has not touched any inflammable matter: for it may be eaſily decompoſed by phlogiſton which unites with the arſenic, ſeparates it from the alkali, and is ſublimed. No pure mineral acid can decompoſe this ſalt, becauſe arſenic ſeems to have a greater affinity with fixed alkali than acids have: but when theſe acids are united with metallic matters, they then eaſily decompoſe the neutral arſenical ſalt, even by the humid way; ſo that a ſolution of this ſalt added to a ſolution of metals occaſions a precipitate compoſed of the arſenic and metal, while the acid of the metallic ſolution combines with the fixed alkali of the neutral arſenical ſalt, and forms another neutral ſalt. Thus two decompoſitions are made, and two new combinations are formed.

The uſes of the neutral arſenical ſalt are not yet well determined; yet as the arſenic ſeems, from the properties mentioned, to be ſtrictly united with the fixed alkali, this ſalt may probably be uſefully employed, 1. for the preparation of the regulus of arſenic; 2. to combine arſenic conveniently with metallic matters; 3. in the compoſition of many glaſſes; 4. as the corroſive mineral acids form very mild ſalts when ſaturated with alkali, we may be induced to believe that arſenic compleatly ſaturated with a fixed alkali, as it is in the neutral arſenical ſalt, might form a very mild ſalt, which may be powerful in medicine; but the name of arſenic is ſo terrible, that it will probably be never tried:

tried: but if it ſhould, very numerous and long trials ought to be previouſly made on animals.

This ſalt might probably be uſeful in arts; for Mr. Beaumé prepares large quantities of it for different manufactures; but the uſes to which it is applied are kept ſecret. *See* ARSENIC.

SALT *of* MILK.

Salt of milk is a neutral ſalt of a ſingular nature, and very little known. It is obtained from whey by evaporation and cryſtallization. As the evaporated whey from which it is obtained has a red color and a ſaccharine taſte, that part of the ſalt of milk, which cryſtallizes firſt, has the ſame color and taſte; and hence it has been called *ſugar of milk*. If it be required more white and pure, it muſt be again diſſolved in pure water, and cryſtallized once or twice; and then it becomes very white, and has a farinaceous appearance even internally, although it is compact and hard. When thus purified, it is leſs ſaccharine, and has in general leſs taſte; becauſe it is diſengaged from the ſaccharine part of the milk, and even from a little common ſalt, which may afterwards be ſeparated from the whey.

Cryſtals of this ſalt ſeem to contain very little water: they have little taſte, are not deliqueſcent, nor very ſoluble, and ſeem to be difficultly decompoſed. They deſerve a farther examination.

Some perſons have imagined, that a liquor like whey might be made by diſſolving ſalt of milk in pure water; but this ſalt is only one of the conſtituent parts of whey; and conſequently the purer it is, the leſs can its ſolution imitate that liquor. *See* MILK.

SAL POLYCHREST.

The word polychreſt is applicable to things which have many uſes: accordingly chemiſts ſay, that a furnace is polychreſt when it is ſo conſtructed that different operations may be made with it.

For the ſame reaſon, the inventors of ſome ſalts have given them this epithet to denote their various powers in medicine. Hence we have the *ſal polychreſt of Glaſer*, which is a vitriolated tartar, made by the detonation of nitre with ſulphur; the *ſal polychreſt of Rochelle* or *of Saignette*, which is a tartareous ſalt, or a ſoluble tartar with baſis of marine alkali. *See* SALT *of* SAIGNETTE, *and* TARTAR (VITRIOLATED).

POTASH.

Potaſh is a purified, fixed, vegetable alkali, obtained from the aſhes of wood. *See* ALKALI (FIXED VEGETABLE).

SALT *of* SAIGNETTE *or of* ROCHELLE.

This salt is a soluble tartar with basis of marine alkali, or a neutral salt formed by saturating the acid of tartar with marine alkali.

This salt was first composed for medicinal purposes, in imitation of ordinary soluble tartar or vegetable salt, by Mr. Saignette, apothecary at Rochelle, who brought it into vogue, and kept it secret as long as he could. Mess. Boulduc and Geoffroy afterwards discovered, and published its composition.

To prepare this salt, crystals of marine alkali are to be dissolved in hot water, and into this liquor powdered cream of tartar is to be thrown: when the effervescence ceases, more cream of tartar is to be added, till the liquor is saturated: it is then to be filtered and evaporated; and very fine and large crystals may be obtained by cold, each of which is the half of a polygonous prism cut in the direction of its axis. This section, which forms a face much larger than the rest, is, like them, a regular rectangle, distinguishable however from the others, not only by its breadth, but also by two distinct diagonal lines which intersect each other in the middle.

Mr. Beaumé has observed, that the crystallization of this salt, and also of the vegetable salt, is much more easy and beautiful when the liquor in which it is made contains an excess of alkali, which does not prevent the salt from being exactly neutral, after it has been well drained.

Salt of Saignette has a saline taste, moderately strong, and disagreeable. It retains much water in its crystallization, is soluble in a less quantity of hot water than of cold water, and consequently crystallizes well by cold. It becomes farinaceous in a dry air, both from the quantity of water of its crystallization, and from the marine alkali which enters its composition. In other respects, it has all the general properties of *neutral tartareous salts*, or *soluble tartars*.

Salt of Saignette is used only in medicine. It is a good purgative, taken from an ounce to an ounce and a half. It is much used as such, and is, for that purpose, dissolved in pure water, or in ptisans and mineral waters, to render them purgative. It is also given in small doses of one or two gros, as an alterative, aperitive, and corrector of other purgative substances. Altho' this salt really possesses these good qualities, it does not seem to differ much from ordinary soluble tartar, to which it is generally preferred. *See* TARTAR, ALKALI (MINERAL), *and* TARTAR (SOLUBLE).

SALES SALSI.

This is one of the names given to neutral salts, particularly to those which have a taste something resembling that of common salt. *See* SALT (NEUTRAL).

SEDATIVE SALT.

This salt is a saline, concrete, and crystallized substance, obtained from borax by means of acids. This matter, although it acts as an acid in borax, and perfectly saturates its alkali, has not an acid taste, nor the property of reddening the tinctures of violets and turnsol, as the acids properly so called do. Sedative salt has little taste and solubility in water. It is a kind of neutral salt, which has only some properties common to it with acids, as we shall afterwards see.

Sedative salt may be obtained from borax by sublimation, or by crystallization. The most common process for obtaining this salt by sublimation is that of Homberg, the discoverer of sedative salt This process consists in mixing martial vitriol with borax, in dissolving them in water, in filtrating and evaporating the liquor till a pellicle appears: the liquor is then to be put in a small glass alembic, and the sublimation is to be promoted till only a dry matter remains in the cucurbit.

During this operation, the liquor passes into the receiver; but the internal surface of the capital is covered with a saline matter forming very small, thin, laminated crystals, very shining and very light. This is the sedative salt. The capital is then to be unluted, and the adhering salt swept off with a feather: the part of the liquor which passed last into the receiver is to be poured on the dry residuum of the cucurbit, and a new sublimation is to be promoted as before, by distilling till the matter in the cucurbit be dry: these operations are to be frequently repeated in the same manner, till no more sedative salt can be sublimed.

Sedative salt may be obtained by crystallization. For this purpose, let borax be dissolved in hot water; and to this solution, when filtrated, add any one of the three mineral acids, a little at a time, till the liquor be saturated, and even have an excess of acid, according to Mr. Beaumé's process: the liquor is then to be left in a cold place, and a great number of small, shining, laminated crystals will be formed: These must be washed with a little very cold water, and drained upon brown paper. This is the sedative salt obtained by crystallization. It is very beautiful and shining, but is somewhat denser than the salt obtained by sublimation. This latter is so light, that one gros is sufficient to fill a large phial.

The acids, either of the martial vitriol, or the disengaged acids in the latter process, do only disengage this salt from the marine alkali with which it formed borax, as Mr. Baron has discovered. Accordingly, this salt, when well prepared, does not partake in any manner of the nature of the acid by means of which it has been disengaged. Sedative salt obtained by crystallization does not differ essentially from that which is sublimed, only that the crystals or laminæ of the latter are more separated and detached than those of the former.

Sedative salt, although it be thus sublimed, is not however volatile; for, as Mr. Rouelle observes, it only rises by means of the water of its crystallization. We know that when once it has lost its water by drying, it cannot be raised

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into vapors by the moſt violent fire, in which it remains fixed, and melts into a vitreous matter, as borax does.

This vitrified ſedative ſalt preſerves its ſaline character; and, although it has a beautiful cryſtalline appearance, it is only ſedative ſalt deprived of all moiſture and melted. It is entirely ſoluble in water, and may then be cryſtallized or ſublimed, as at firſt, into its proper form.

A great quantity of water is required to diſſolve ſedative ſalt, and much more of cold than of boiling water. It may therefore be cryſtallized by cold, and is alſo cryſtallizable by evaporation alone.

Mr. Beaumé has made an intereſting obſervation upon this method of diſengaging and cryſtallizing ſedative ſalt, which is, that we muſt add a little more acid to the ſolution than is ſufficient for the ſaturation. He remarks, that when only the preciſe quantity of acid is added to decompoſe all the borax, the ſedative ſalt remains confounded with the other ſaline matters contained in the liquor, and the cryſtallization is conſequently diſturbed. This inconvenience is avoided by the addition of a little more acid than is ſufficient for the ſaturation of the alkaline baſis of the borax. The ſedative ſalt, although formed in a liquor thus acidulated, may be entirely deprived of any exceſs of acid, which is not combined with it, by means of draining upon paper, according to the principles of Mr. Beaumé.

The acid that is mixed in the hot ſolution of borax decompoſes this ſalt, becomes ſaturated with its alkaline baſis, and inſtantly diſengages the ſedative ſalt; all which is effected without any efferveſcence. The ſedative ſalt does not cryſtallize as ſoon as it is diſengaged, although the liquor be at the point of cryſtallization, when only the preciſe quantity of water is added which is neceſſary for the ſolution of the borax. The heat is the cauſe of this; for as ſoon as the liquor cools, a conſiderable quantity of cryſtals is perceived.

From the above-mentioned properties of the ſedative ſalt, by which it reſiſts fire, ſo as to be capable of vitrification, without being otherwiſe altered, we may perceive that it is a ſaline compound, the principles of which are ſtrictly united, and very difficultly ſeparable. This truth has been illuſtrated by numerous and accurate experiments on this ſubject by Mr. Bourdelin, related in the Memoirs of the Academy for the years 1753 and 1755.

From theſe experiments we find, that ſedative ſalt reſiſts the moſt powerful agents for the decompoſition of ſaline ſubſtances. It was unaltered by treatment with inflammable matters, with ſulphur, with mineral acids diſengaged, or united with metallic ſubſtances, and with ſpirit of wine. Mr Bourdelin could only perceive ſome marks of an inflammable matter, and a little marine acid, in this ſalt. The former he diſcovered by a ſmell of ſulphureous acid communicated by it to vitriolic acid; and the latter by a white precipitate formed in a ſolution of mercury, by the liquor obtained from the diſtillation of a mixture of this ſalt with powder of charcoal. Mr. Bourdelin does not poſitively affirm the laſt propoſition; but acknowledges, with all chemiſts, that we do not know the nature of ſedative ſalt, from not having been able to decompoſe it.

As this ſalt has the property of diſengaging the acids of nitre and of common ſalt by uniting with their baſes, and alſo as it is very vitrifiable, and promotes

motes the vitrification of other substances, most chemists believe that it is composed of vitriolic acid intimately combined with a fusible and vitrescible earth.

This is one of the salts which are soluble in spirit of wine, to the flame of which it communicates a green color. As only the saline combinations of copper are known to be capable of giving this color to the flame of spirit of wine, some chemists have been induced to believe, that sedative salt might contain copper, or the calx of copper.

Lastly, we may suspect some analogy betwixt the sedative salt, on one side, and arsenic and phosphoric acid on the other, from some properties which each of these substances have, and particularly from their action upon certain salts, and from their vitrescible quality. But these latter substances are not better known than sedative salt; therefore all that we can say upon this subject is, that much yet remains to be discovered concerning all these matters.

Excepting the uses of borax in vitrifications, and in fusions and soldering of metals, sedative salt is only employed in medicine. Homberg, its inventor, believed that he discovered in it a sedative, antispasmodic, and even narcotic quality, and thence called it the *narcotic salt of vitriol*.

It was generally employed in convulsive diseases after the praises Homberg had bestowed upon it; but its sedative powers have not been well ascertained. The best practitioners even affirm, that, to produce any effect, it must be given from half a gros to a gros, instead of doses of a few grains, which were given at first. *See* BORAX. (*t*)

SALT *of* SODA.

This is one of the names given to marine or mineral alkali obtained from the ashes of soda and of other maritime plants. *See* ALKALI (MINERAL).

SULPHUREOUS SALT *of* STAHL.

This name is given to a neutral salt, composed of volatile sulphureous acid, combined to the point of saturation with fixed vegetable alkali.

(*t*) SEDATIVE SALT. Mr. Cadet has published, in the Memoirs of the Royal Academy of Sciences for the year 1766, an account of some experiments made by him upon borax and the sedative salt. From these he infers, 1. that the acid contained in borax is the marine, he having made a corrosive sublimate with this acid and the mercurius precipitatus per se. 2. That the sedative salt does not exist in borax, but is produced during the process. 3. That this sedative salt is composed of the marine acid originally existing in the borax, of the vitriolic acid employed in the operation, and of a vitrescible earth. 4. That this vitrescible earth is the same as that which is generally separated from borax during its solution in water, and which abounds more in the unrefined than in the refined borax. 5. That this earth consists of a calx of copper, from which by reduction he obtained a regulus of copper. 6. That borax therefore is composed of a calx of copper united with marine acid, and with mineral alkali. The same chemist purposes to make further experiments on this singular salt.

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This salt may be made either by saturating fixed alkali with volatile sulphureous acid made in a cracked retort, in Stahl's manner, or by exposing linen soaked in liquid fixed alkali to the vapors of sulphur slowly burning. When this latter method is employed, the linen dries, becomes stiff, and shines with many small, needle-like crystals, which are the sulphureous salt.

Volatile sulphureous acid does not differ from pure vitriolic acid but by a portion of phlogiston, which is only weakly united with it, but is however sufficient to disguise considerably the essential properties of this acid. Sulphureous vitriolic acid has not only a pungent smell and volatility which the pure vitriolic has not, but it also forms with different substances, particularly with fixed alkali, neutral salts very different from those formed by the union of these substances with pure vitriolic acid. Stahl first observed this salt, which is the only one known of all the combinations of the sulphureous acid.

This sulphureous salt has a more pungent taste than vitriolated tartar, is more soluble in water, and is crystallizable by cold. Its crystals are like needles attached to each other by their ends, forming tufted clusters of crystals; in which respect also it differs from vitriolated tartar, and is somewhat analogous to nitre.

This salt may be decomposed by any acid, and its sulphureous acid expelled from it. Thus vitriolic acid, from being naturally the strongest of any, is rendered the weakest of all, merely by union with the inflammable principle, which is only weakly combined with it.

The natural volatility of the phlogistic principle, and its weak adhesion to the volatile sulphureous acid, occasion a gradual change of the nature of the sulphureous salt. This salt is perpetually changing, from the constant dissipation of its phlogiston. It gradually loses its peculiar properties by which it differs from vitriolated tartar, becomes more and more similar to this salt, and at last, when it has lost all its phlogiston, does not in any respect differ from it. Probably we might observe the same changes in the combinations of sulphureous acid with other substances; nevertheless those which, like metals, have a stronger affinity with phlogiston than alkali has, may perhaps produce effects very different.

All the phenomena of the sulphureous salt, of the volatile sulphureous acid, and of sulphur, with regard to their several combinations, are naturally deducible from this general principle, that the affinities of the most compound bodies are always weaker than those of the most simple substances. *See* VOLATILE SULPHUREOUS ACID, *and* ACID (VITRIOLIC).

FEBRIFUGAL SALT *of* SYLVIUS.

This is a neutral salt composed of marine acid saturated with fixed vegetable alkali. It is also called *regenerated sea salt*, but improperly, because the basis is different from that of sea salt. Excepting its taste, which is not so agreeable as that of sea salt, it resembles this salt in its crystallization, and in most of its essential properties. It does not seem to deserve the epithet *febrifugal*, although it may, when given in proper doses as a purgative and antiseptic, contribute

contribute to the cure of ſome fevers, which qualities are common to it with other neutral ſalts. It is not now employed. *See* ACID (MARINE), ALKALI (FIXED), *and* NEUTRAL SALTS.

SALTS *of* TAKENIUS.

The ſalts prepared in Takenius's manner are impure fixed alkalis, obtained from the aſhes of vegetables burnt for that purpoſe in a peculiar manner, namely, by ſuffocating their flame, and leaving no more communication with the air than is ſufficient for the burning of their moſt diſengaged inflammable parts.

When therefore we would prepare the fixed ſalts of a plant according to this method, the dried plant is put in an iron pot, which is to be heated ſo that its bottom ſhall be red. The plant muſt be continually ſtirred; a thick ſume will exhale from it, and at length a flame riſes. The pot is then to be covered with a lid, which muſt be ſo looſe that the flame only will be extinguiſhed, and the ſmoke will paſs out. The lid muſt be taken off ſometimes, that the plant may be ſtirred. When the plant is by this method reduced to a kind of aſhes, theſe aſhes muſt be lixiviated with boiling water; and when the lixivium has been evaporated to dryneſs, a ſaline matter more or leſs reddiſh will remain, which ought to be kept in a bottle. This is the fixed ſalt of the plant prepared in Takenius's method.

By burning plants in this manner, the fixed alkali obtained is evidently phlogiſticated, rendered ſemi-ſaponaceous, ſimilar to that which is prepared for the making of Pruſſian blue, and mixed with all the neutral ſalts contained in the plant. Theſe impure alkalis have been intended only for medicinal uſes. Some perſons have imagined that they could retain much of the virtue of the plant from which they have been obtained. But although we do not doubt that the fixed ſalts of different plants, prepared in this method, differ conſiderably from each other; yet as the medicinal virtues of vegetables depend chiefly on their proximate principles, and as theſe principles are totally changed, and decompoſed by burning, even when they are made with the precautions which Takenius mentions, theſe ſalts retain none of the virtues of the plants from which they are produced when alkalis are required. They are only ſemi-ſaponaceous fixed alkalis, much leſs cauſtic than well purified alkalis, and which therefore may be preferred in medicine. Theſe alkalis partake beſides of the virtues of the neutral ſalts with which they are mixed.

SALT *of* TARTAR.

This name is commonly given to the fixed alkali of tartar, and even frequently to fixed vegetable alkali in general. *See* ALKALI (FIXED).

VEGETABLE SALT.

This ſalt, called alſo *ſoluble tartar*, and *tartariſed tartar*, is a combination to the point of ſaturation of cream of tartar, or acid of tartar with fixed vegetable

table alkali. It is prepared and cryſtalliſed like ſalt of Saignette, from which it differs in its alkaline baſis. The cryſtals of this ſalt are much ſmaller than thoſe of ſalt of Saignette. In other reſpects it has the ſame properties, chemical and medicinal. *See* SALT *of* SAIGNETTE, TARTAR, *and* TARTAR (SOLUBLE).

SALT *of* VINEGAR.

The ſalt ſold by apothecaries under this name is nothing but vitriolated tartar, impregnated with very ſtrong radical vinegar.

As pure radical vinegar cannot be obtained in a concrete ſtate but with very great difficulty, and as it does not retain this concrete ſtate when it has once received it, as the Count de Lauraguais has ſhewn, when a ſalt of vinegar is required with a very pungent and penetrating ſmell, to be kept in bottles, like the concrete volatile alkali called ſalt of England, a better expedient has not been found than that we have mentioned. This mixture has a ſmell of radical vinegar, almoſt as pungent as that of volatile alkali, although the kind be very different; and is applicable to the ſame purpoſes, namely, to relieve hyſterical paroxyſms. *See* VINEGAR.

VOLATILE SALTS.

This name is frequently given to volatile concrete alkaline ſalts. Thus *volatile ſal ammoniac*, and *volatile ſalt of hartſhorn*, are the volatile alkalis obtained from theſe ſubſtances. Nevertheleſs, the ſame name is ſometimes given to other ſaline ſubſtances of very different natures, for inſtance, *the ſalt of amber*, which is acid, and is called *volatile ſalt of amber*, which is certainly an inconvenience. The appellation *volatile ſalt* may be given to all ſaline matters really volatile, that is, which may be ſublimed with a moderate heat. But as theſe ſalts are of very different kinds, they ought to be diſtinguiſhed by ſome more particular name. The volatility of ſalts is a very indeterminate quality. For of thoſe which are conſidered as ſuch, ſome are much more, and ſome much leſs volatile than others.

Theſe ſalts are called *ſemi-volatile* which cannot be ſublimed without a fire ſufficient to render the bottom of the veſſel containing them red-hot, ſuch as moſt ammoniacal ſalts, ſweet mercury, and ſome others. And thoſe are called *fixed ſalts* which may be kept red-hot during a certain time without ſenſible loſs. But, rigorouſly ſpeaking, no ſalts are abſolutely fixed; for, as we have ſaid elſewhere, the alkalis called fixed, and the other ſalts which are conſidered alſo as fixed, are diſſipated in fume when long expoſed to violent fire, with acceſs of air. *See* ALKALIS (VOLATILE), FIXITY, VOLATILITY.

URINOUS SALTS.

This name was given by ancient chemiſts to all alkaline ſalts, volatile or fixed; to the former, becauſe they all have the taſte of putrefied or diſtilled urine;

urine; and to the fixed, becauſe although they have not themſelves this taſte, they however occaſion it, when applied to the tongue, by diſengaging the volatile alkali contained in animal ſubſtances. Therefore *urinous ſalts* and *alkaline ſalts* are ſynonimous. *See* ALKALI.

SALT *of* STEEL.

Some chemiſts have given this name to ſeveral combinations of iron with acids, even to martial vitriol, as appears from *Riverius's ſalt of ſteel*, which is a martial vitriol made with iron, vitriolic acid, and ſpirit of wine. *See* VITRIOL.

DCIX. SALT-PETRE. *See* NITRE.

DCX. SAND. Sand is compoſed of ſmall ſtoney matters. The kinds of ſand may therefore be as many as the kinds of ſtones. Moſt ſands conſiſt of different kinds of ſtones mixed together. But as ſoft ſtones are eaſily reducible into ſo ſmall particles, that they are more like powders or earths than ſand; and as the molecules of hard or vitrifiable ſtones are capable of preſerving longer their ſize; hence moſt matters called ſand are of the nature of vitrifiable earths. *See* EARTHS (VITRIFIABLE). Accordingly, by the name of ſand, we underſtand always, in natural hiſtory and in chemiſtry, a matter of the nature of vitrifiable earths.

The principal uſe of ſand in chemiſtry is in compoſitions for pottery and glaſs. Some ſands are more and ſome leſs fuſible. The particles alſo of ſome are larger than thoſe of others. The finer kind is generally uſed for vitrifications, and other chemical operations, becauſe it is naturally much divided: It is frequently employed to make a *ſand-bath* to tranſmit heat to veſſels placed in it.

DCXI. SANDARACH. This is a yellow or red combination of arſenic with ſulphur. *See* ARSENIC, *and* REALGAR.

DCXII. SANDIVER. *See* GLASS-GALL.

DCXIII. SAPHIRE. (*u*)

DCXIV. SARCOCOLLA. (*x*)

DCXV. SARSAPARILLA. (*y*)

DCXVI. SASSAFRAS. (*z*)

(*u*) SAPHIRE is the name of a pellucid blue gem, the hardneſs of which is next to that of the ruby. By fire it is unfuſible, but its color is thereby deſtructible. It may be imitated by fuſing a hundred parts of cryſtal-glaſs-fritt with one part of zaffre, and a very ſmall proportion of manganeſe.

(*x*) SARCOCOLLA is a gum-reſin, of an ounce of which ſix drams were found to be ſoluble by ſpirit of wine; and ſeven drams and a half were found to be ſoluble by water. *Neuman.*

(*y*) SARSAPARILLA. From ſixteen drams of this root Neuman obtained by water ſix drams of gummy extract, and from an equal quantity he obtained by ſpirit four drams of reſinous extract.

(*z*) SASSAFRAS. The wood of this tree contains the heavieſt of all known eſſential oils. Of this oil Hoffman obtained an ounce and ſix drams from ſix pounds of the wood; and Neuman obtained from an equal quantity of wood, two ounces. From an ounce of ſaſſafras four ſcruples of extract were obtained by means of rectified ſpirit; and from an equal quantity of the wood, two drams were extracted by water. *Neuman.*

DCXVII. SATURATION. All the particles of matter have, as is said under the articles AFFINITY, COMBINATION, SOLUTION, *and* GRAVITY, a tendency to unite one with another. In fact, when they are united, and when this tendency is satisfied, it is called the state of *saturation*, and then the whole effect of this tendency, or of this force, consists in making them cohere together. But all the phenomena of chemistry show, that the tendency to union of the parts of different substances is more or less strong, according to the nature of these substances. Hence the parts of two substances may be united together with all the force of which they are susceptible, respectively to each other, although their tendency to union in general be very far from being entirely exhausted and satisfied.

This remark leads us to consider saturation in two views, that is, that we should distinguish the saturation of one substance relatively to another, from the greater or less diminution of tendency to union in general, which a substance has sustained by means of any particular union contracted. This latter we shall call *absolute saturation*, and the former *relative saturation*.

These things being premised, as the general tendency to union diminishes always in proportion to the force with which the parts are united, hence the adhesion, more or less strong, contracted betwixt the principles of any compound, influences much the nature and essential properties of this compound; for example, when the principles of a body are capable of uniting together with all their general tendency to union, their relative saturation is then confounded with their absolute saturation, so that after their union, no tendency to new unions can be perceived in these bodies, or in any of their principles. Such are the neutral salts composed of mineral acids and fixed alkali. So strong an union is contracted by the acid and alkaline principles of these salts, that they lose entirely, or almost entirely, their taste, causticity, activity; in a word, all the properties which before this union were occasioned by their general tendency to combination. Accordingly, the relative saturation of these is very distinct, and is one of the first which has been observed.

When, on the contrary, the principles of a compound can contract together only a weak union, and consequently do not exhaust by this union all their general tendency to combination, not only their point of relative saturation is less distinct, but also these principles, although relatively saturated by each other, are far from absolute saturation, and still preserve, notwithstanding this union, much of their dissolving power. Compounds of this kind are always considerably active, and even caustic according to the nature of their principles. Such are deliquescent salts, and particularly most salts composed of mineral acids and metallic substances, the causticity of which cannot be otherwise explained. *See the articles* CAUSTICITY, *and* SUBLIMATE (CORROSIVE).

Many substances have a determinate and considerably distinct point of relative saturation, altho' they contract together but a weak union. But if we attend, we shall perceive that all these substances possess but a small quantity of dissolving power, or a weak general tendency to combination. Their relative saturation is nearly equal to their absolute saturation. Such are ether with water, essential oils with spirit of wine, and most neutral salts with water. If we mix together and agitate good ether with water, a part of the ether unites with

with the water, nearly in the proportion of one to ten; ſo that if one part of ether be added to ten parts of water, all the ether diſappears by being diffuſed through the water, as the Count de Lauraguais obſerves. If the quantity of ether be more than one tenth part of the water, the overplus will float diſtinct upon the ſurface of the water, like an oil.

Alſo well rectified ſpirit of wine can only diſſolve a determinate quantity of each kind of eſſential oil, which quantity varies according to the kind of oil, and to the ſtate in which it happens to be. In general, the more attenuated they have been by rectification, the more they are removed from a reſinous ſtate, and the ſmaller quantity of them is ſoluble. And alſo the more highly rectified a ſpirit of wine is, the larger quantity of oil it diſſolves.

Water is the proper ſolvent of neutral ſalts. It is capable of diſſolving any of them, but moſt of them only in a certain quantity: and this point of ſaturation of water differs with different ſalts, and degrees of heat applied. The point of ſaturation is moſt diſtinct with thoſe ſalts which contain a ſmall quantity only of the water of cryſtallization, and which are nearly equally ſoluble in hot and in cold water. Such are vitriolated tartar, and, ſtill more, common ſalt.

When the water is once ſaturated with theſe kinds of ſalts, the ſtrongeſt and longeſt boiling does not diſſolve a grain more, and the overplus of the ſalt remains entire at the bottom of the boiling water: But boiling water diſſolves an equal, or even an unlimited quantity of ſome ſalts, chiefly of thoſe which contain much water in their cryſtallization, ſuch as Glauber's ſalt, alum, borax, martial and cupreous vitriols, and others of that kind. The water of cryſtallization of theſe ſalts is alone ſufficient to keep them diſſolved, by means of heat. Hence, when they are expoſed to fire without water, they ſuffer a liquefaction, which is very different from fuſion, and is nothing elſe than a ſolution of the ſalt in the water of its cryſtallization, and conſequently laſts only till this water be evaporated. The point of ſaturation of water for theſe ſalts ſeems to be indeterminate.

Many ſubſtances are capable of uniting without being preciſely ſaturated, ſuch as water with any of the following ſubſtances; fluor acids, fixed vegetable alkali, fluor volatile alkali, moſt of the very deliqueſcent neutral ſalts, and ſpirit of wine. Such alſo are almoſt all metals uniting with each other: Although many of theſe ſubſtances have a great affinity together, as the fluor acids and alkalis with water, yet all their general tendency to combination is not exhauſted in theſe kinds of union. On the contrary, their union is little elſe than a very accurate and intimate mixture. Their diſſolving power is not ſatisfied by ſuch an union, but is almoſt entirely preſerved. We need not therefore be ſurpriſed, that no preciſe or determinate point of ſaturation is obſerved betwixt theſe ſubſtances. We may ſay, in general, that the point of relative ſaturation is ſo much more exact, diſtinct, and determinate, as the bodies which unite together have a ſtronger affinity, as they more compleatly exhauſt upon each other their diſſolving power, or as their relative ſaturation is more nearly equal to their abſolute ſaturation.

The examination of the ſeveral degrees of ſaturation which ſubſtances may ſuſtain by combining together, is an object as important as it is new in chemiſtry. This matter has been ſcarcely begun, and yet it well deſerves the attention of chemiſts, as it would greatly advance the ſcience. We could not

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treat this subject more fully without repeating what has been said elsewhere. We therefore refer to the articles *affinity*, *combination*, *composition*, *solution*, *causticity*, *gravity*, *salts*, *neutral salts*, *corrosive sublimate*; and several others.

DCXVIII. SAUNDERS. (a)

DCXIX. SCAMMONY. (b)

DCXX. SCORDIUM. (c)

DCXXI. SEA-WATER. *See* WATER.

DCXXII. SELENITES. Modern chemists give this name to a sort of neutral salt formed by the union of vitriolic acid with any calcareous earth. Vitriolic acid and calcareous earth are capable of combining together to the point of saturation in the most intimate manner. Probably a very considerable quantity of earth enters into this combination, at least if we judge of it by the saturation of vitriolic acid, which appears to be more compleat than in any of the other neutral salts formed with this acid. This truth is sufficiently established by the properties of selenites.

Nature furnishes us with a very large quantity of selenitic matters. Chemists agree that all gypsums or plaster-stones, alabasters, and gypseous spars, are nothing else than selenites; but these substances are in large quantities within and upon the earth. We may also artificially compose selenites, by combining vitriolic acid to the point of saturation with calcareous earth. To effect this saturation easily, the calcareous earth must be in fine powder, the acid must be diluted in a very large quantity of water, and more earth must be added than is necessary for the saturation. Selenites may also be conveniently made by

(a) SAUNDERS. The wood of the tree, called *red saunders*, contains a red coloring material used in dying. Its color resides wholly in a resinous matter, and hence is extractable by spirit of wine, and not by water. The red color of Saunders, imparted to spirit of wine, becomes, by diluting the tincture with more spirit, yellow. The resin gave a deep red color to oil of lavender, and a pale red to oil of almonds and to oil of aniseeds, but no color to oil of amber and to oil of turpentine. The wood of the tree, called *yellow saunders*, is from its fragrance sometimes employed as a perfume. From sixteen ounces of the rasped wood, digested some days in salt water, two drams of essential oil were obtained by cohobation. Two drams of gummy extract may be obtained from two ounces of the wood, by water; and from an equal quantity of wood, two drams and a half of resinous extract may be obtained by rectified spirit. *Neuman.*

(b) SCAMMONY is a gummy-resinous juice, which exsudes from the root of a species of convolvulus, in which incisions are purposely made at a certain season of the year. An ounce of Smyrna scammony yielded with water half an ounce of gummy extract, and the residuum yielded with spirit two drams of resin, leaving two drams of impurities undissolved. By applying rectified spirit at first to an ounce of the same scammony, two drams, and two scruples of resinous extract were obtained; and from the residuum, water extracted half an ounce of gum, the indissoluble part amounting here to four scruples only. *Neuman.*

(c) SCORDIUM. An ounce of the dried leaves of scordium yielded with water four drams and a half of gummy extract, and afterwards with rectified spirit fifteen grains of resin. Another ounce, treated first with spirit, gave three drams of resinous extract, and afterwards with water, five scruples and a half of gum. A tincture, made in highly rectified spirit of wine, contains more of the active and less of the mucilaginous parts of this plant, than one made with a weaker spirit.

saturating

faturating lime-water gradually with weak vitriolic acid, or, laftly, by pouring this acid into a folution of nitrous or marine falts with calcareous bafes. In thefe latter operations the felenitic falt renders the liquor turbid, and is precipitated.

Selenites, natural or artificial, when well wafhed from all excefs of acid or other extraneous matter, has a flightly naufeous tafte, which is fcarcely perceptible but by drinking a glafs of water impregnated with it, like that of the wells in and near Paris, the fweetifh and flightly naufeous tafte of which is well known.

This earthy falt is one of the leaft foluble by water of all the known neutral falts. Seven or eight hundred parts of water are required to diffolve one part of felenites, excepting when its principles are combined, and the falt formed in the water, as Mr. Beaumé has obferved; for then the water may diffolve four or five times as much. By a flow evaporation it cryftallizes, and forms thin laminæ, and retains in its cryftallization a very fmall quantity of water.

When it is expofed to a moderate fire, it eafily lofes this water of its cryftallization with its tranfparency and cohesion of its parts, and is reduced to a white powder.

With a very great fire, it is not fufible when alone, (*d*) but is more eafily fufible than pure calcareous earth, by the addition of fluxes, as fand, and clay, and vitrifying falts. It refifts the greateft heat without lofing its acid. It cannot be decompofed but by phlogifton, by alkalis fixed or volatile; and by metallic folutions in nitrous acid, by means of a double affinity. Thus the folution of mercury readily fhews whether a water be felenitic or not, by forming a precipitate of turbith mineral when added to fuch waters. As felenitic matters are copioufly diffufed, and almoft every where within the earth, moft waters of wells, of rivers, contain a greater or lefs quantity of felenites diffolved in them, as we may eafily find by the abovementioned method of trial.

Nothing better fhews the extreme difference betwixt vitriolic and other mineral acids, than the comparifon of the faline properties of felenites with thofe of nitrous and marine falts with calcareous bafes. The earthy bafis is the fame in thefe three falts; but the two latter have a violent, almoft cauftic tafte, and are furprifingly deliquefcent; while the firft falt is very difficultly foluble in water, and almoft infipid. The caufe of thefe differences is, that vitriolic acid is more fimple than the other acids, and is therefore capable of being more intimately combined and faturated with calcareous earth.

This kind of falt has been called felenites probably becaufe naturalifts found its faline properties fo weak, that they thought it ought to be diftinguifhed from other neutral falts by a peculiar name. Perhaps they did not even believe it to be faline; for the nature of felenitic matters has been difcovered but lately by experiments of modern chemifts.

We are not yet enough acquainted with calcareous earths to know if felenites be of different kinds, or if all the fubftances to which this name is given are only one and the fame falt under different forms of cryftallization. If the kinds of calcareous earth be effentially different, they muft form with vitriolic

(*d*) From Mr. D'Arcet's Memoir upon the effects of a violent and long continued heat, we find that all gypfeous ftones, and alfo the artificial felenitic falts, are fufible and vitrefcible by violent fire.

acid

acid feveral kinds of felenites alfo effentially different from each other. But if only one kind of calcareous earth exifts, then it can only form one kind of felenites.

We may obferve, that amongft the various bodies called by chemifts felenites, that is, compounds of vitriolic acid with calcareous earths, fome differ much from others, at leaft externally. Thefe fubftances are all the gypfums, alabafters, and fpars, which fome chemifts, particularly Mr. Pott, have called gypfeous, and, laftly, fome cryftallizations and ftalactites, which have the fame principles and the fame effential properties as other felenitic fubftances. *See* ACID (VITRIOLIC), ALABASTER, GYPSUM, SPAR, *and* EARTH (CALCAREOUS).

DCXXIII. SEMI-METAL. Subftances poffeffing all the metallic properties, excepting fixity and ductility, are called *femi-metals.* Thus every matter poffeffed of metallic denfity, opacity, and luftre, which is incapable of uniting with earths, but which is alfo brittle and frangible by the ftroke of a hammer, and capable of being fublimed or reduced into vapors by fire, is a femi-metal. Hitherto we know but five femi-metals, which are *regulus of antimony, zinc, bifmuth, regulus of cobalt, and regulus of arfenic.*

Some chemifts have numbered mercury amongft the femi-metals, under pretence that it poffeffed all the metallic properties excepting fixity and ductility: but all femi-metals are combuftible, and mercury is no more fo than the perfect metals; and alfo, the want of ductility is falfely imputed to it, fince the Academicians of Peterfbourg, who fome years ago fixed it, found it ductile and malleable. If mercury then be not ductile in its ordinary ftate, the caufe of this appears to be, that it is really in fufion: but the moft ductile metals lofe their ductility by fufion, as this quality neceffarily implies folidity. On the other fide, the great volatility of mercury does not allow us to clafs it among metals. This metallic fubftance is therefore fingle in its kind, and is really neither a metal nor a femi-metal. *See* MERCURY.

Mr. Cronftedt has given, in the Memoirs of the Swedifh Academy for the year 1751, a defcription of a new femi-metal: but this metallic fubftance is hitherto but little known. (e)

DCXXIV. SENA. (f)

(e) Concerning this new femi-metal difcovered by Mr. Cronftedt, *fee the article* NICKEL. *See alfo the note (y) to the article* METALS, concerning another new femimetal which Mr. Jufti fays that he has difcovered in the yellow mica.

(f) SENA. An ounce of the leaves of Sena, treated with frefh parcels of rectified fpirit of wine, yielded two drams and twenty-three grains of refinous extract; and afterwards with water, two drams and two fcruples of gummy extract, three drams and three grains remaining undiffolved. Another ounce, treated firft with water, gave four drams and half a fcruple of gummy, and afterwards with fpirit only, twenty-eight grains of a refinous extract, which appeared to contain fome grofs oily matter; and hence was difficultly reduced to drynefs. The refiduum weighed three drams and a fcruple. Water diftilled from Sena poffeffes the peculiar fmell of thefe leaves, but no effential oil appears. The activity of Sena is greatly weakened by evaporation, efpecially if the procefs be performed in an open veffel with a boiling heat. *Neuman.*

Silica see Earth vitrifiable. p. 230.

DCXXV. SENEGAL (GUM) (*g*)

DCXXVI SERPENTINE-STONE. (*b*)

DCXXVII. SILK. (*i*)

DCXXVIII SILVER. Silver, called alſo *luna* by chemiſts, is a perfect metal, of a ſhining white color.

Its ſpecific gravity is, although conſiderable, nearly one half leſs than that of gold. It loſes in water an eleventh part of its weight. A cubic foot of ſilver weighs 720 pounds.

The tenacity of its parts is alſo nearly one half leſs than that of gold; a ſilver wire, the diameter of which is $\frac{1}{10}$ part of an inch, can ſupport only a weight of 270 pounds without breaking.

This metal is, next to gold, the moſt ductile of all. Very fine wire and leaf may be formed of it.

It is ſomewhat ſonorous and harder than gold, as Juncker obſerves; and is fuſible with a leſs degree of heat than gold is, according to Cramer. It ſeems to be as fixed and indeſtructible as gold is. Kunckel kept ſilver and gold in a glaſs-houſe-furnace during a month without alteration, or more loſs than of a few grains, which probably proceeded from a ſmall quantity of extraneous matter, with which it was mixed.

Juncker nevertheleſs affirms, that ſilver may be changed into a vitreſcent calx, when treated by a long reverberation in the manner of Iſaacus Hollandus. This reverberation, conſiſts in expoſing metals, reduced into very fine parts, to the action of the ſtrongeſt heat they can ſuſtain without fuſion, with the contact of free air. This method is very effectual for burning the inflammable principle of metals and of all other bodies. But Juncker does not mention the author of this experiment.

The combined action of air and water does not alter the color and brilliancy of ſilver, nor occaſion any ruſt. Nevertheleſs, the ſurface of this metal is apt to tarniſh, and even to become black, by the contact of the phlogiſton of ſeveral inflammable matters, or of their exhalations; becauſe it has the property of impregnating itſelf with the inflammable principle ſuperabundantly, even in the cold, like ſome other metallic matters: but ſilver ſeems to be more ſuſceptible of this effect than any other metal.

All acids are, with more or leſs facility, capable of diſſolving ſilver.

Vitriolic and marine acids may be combined with ſilver in its metallic ſtate; but difficultly, and by particular management.

To diſſolve ſilver directly, vitriolic acid muſt be much concentrated and very hot; and therefore diſtillation is neceſſary, as in the operation of turbith mineral. *See* TURBITH MINERAL.

(*g*) SENEGAL (GUM) is a gum, almoſt pure, and entirely ſimilar in properties to the other pure gums, as gum arabic, cherry-tree and plumb-tree gums. *See* GUM.

(*b*) SERPENTINE STONE is a ſteatites variouſly colored, but in which the green color generally predominates. *See* STEATITES.

(*i*) SILK is an animal ſubſtance, from 16 oz. of which may be obtained, by diſtillation, nine ounces of mixed matters, containing four ounces and two drams of urinous ſpirit, three ounces ſix drams of volatile ſalt, and one ounce of empyreumatic oil. The caput mortuum weighed ſeven ounces, and loſt an ounce on being calcined to whiteneſs. By elixating the calx, forty grains of fixed ſaline matter were alſo obtained. *Neuman.*

The marine acid cannot attack ſilver directly; but when it is very much dephlegmated, and, as it were, in a dry ſtate, conſiderably hot and reduced to vapor, as is done by the royal cement in *concentrated parting*. *See* PARTING (CONCENTRATED).

But ſilver may be combined with the above-mentioned acids, by methods much more ſimple and convenient, which we ſhall deſcribe, after having ſpoken of the ſolution of ſilver by nitrous acid.

Nitrous acid, very pure and moderately ſtrong, diſſolves ſilver in its metallic ſtate with the greateſt facility. This ſolution is made ſpontaneouſly without heat, or with a very gentle heat at firſt; and when the ſilver has begun to diſſolve, the heat ought to be diſcontinued, to prevent the ſolution from being too violent, eſpecially if the quantities operated upon be conſiderable.

By this method nitrous acid may be ſaturated with ſilver; and if it be ſtrong, it will diſſolve a conſiderable quantity of that metal.

If the ſilver thus diſſolved be allayed with copper, the ſolution will be green, and will preſerve this color. If it contain no copper, the ſolution is at firſt greeniſh, which color gradually diſſipates, and at laſt the liquor becomes quite white.

The ſurface of the ſilver begins to become black as ſoon as the acid makes impreſſion upon it. This blackneſs proceeds from a part of the phlogiſton of the nitrous acid, which is applied ſuperabundantly to the ſurface of the ſilver.

Black flocks are frequently ſeen floating in this ſolution, which are inſoluble by nitrous acid, and precipitate to the bottom. Theſe flocks may be a ſmall quantity of gold from which ſilver is ſeldom entirely free, or of ſome other phlogiſticated ſubſtance, inſoluble in nitrous acid.

The ſolution of ſilver by nitrous acid is more acrid and corroſive than pure nitrous acid; which property is very remarkable, and is common to it with ſeveral other combinations of metals. *See an explanation of this property under the article* CAUSTICITY.

This ſolution of ſilver corrodes all vegetable and animal matters, and ſtains the ſkin of a black color, which cannot be effaced till the blackened part be abraded. This blackneſs can be only attributed to the phlogiſton of corroded matters, which unites ſuperabundantly with the ſilver of the ſolution employed.

If a ſolution of ſilver by nitrous acid be ſufficiently evaporated, and left to cool, a large quantity of white cryſtals will be formed in it, like ſcales, which are commonly called *cryſtals of ſilver*. Theſe cryſtals are a nitrous ſalt, the baſis of which is ſilver; for which reaſon it may alſo be called *nitre with baſis of ſilver*, or *lunar nitre*.

This ſalt is fuſible with a ſmall heat, and eaſily loſes the water of its cryſtallization. It becomes black, congeals by cold, and is capable of being moulded. It is then the famous cautery uſed by ſurgeons, and known by the name of *lapis infernalis*. *See the words* PARTING, CRYSTALS *of* SILVER, *and* LAPIS INFERNALIS.

Lunar nitre deflagrates upon coals almoſt as well as the nitre with baſis of fixed alkali, which ſhews a ſtrong adheſion of nitrous acid with ſilver. Nevertheleſs, this ſalt expoſed to ſtrong fire in diſtilling veſſels, or in a crucible, may be eaſily decompoſed. The acid quits the ſilver, and appears in its former ſtate.

Although ſilver, as we have ſeen, is more eaſily ſoluble in nitrous acid than in vitriolic and marine acids, we ought not thence to conclude, that this metal has, with the nitrous acid, a greater affinity than with the two others. On the contrary, the two latter acids are capable of ſeparating it from the nitrous acid, after this has diſſolved it.

If vitriolic acid be poured into a ſolution of ſilver in nitrous acid, and if it be not diluted in too great a quantity of water, we ſee immediately the liquors become turbid, and a white precipitate appears, which is nothing elſe than a new combination made of the ſilver which quitted the nitrous acid to unite with the vitriolic acid, and to form with it a new ſalt with metallic baſis. This ſalt, which may properly be called *vitriol of ſilver*, or *lunar vitriol*, is cryſtallizable, and actually does cryſtallize in the very inſtant of precipitation; but the cryſtals are ſo ſmall, from the rapidity of the cryſtallization, that they have only the appearance of a white powder. They cannot be diſcovered to be cryſtals but by means of a good magnifying glaſs.

The ſame event happens, if, inſtead of vitriolic acid, a ſolution of any ſalt containing that acid be added to a ſolution of ſilver in nitrous acid. The nitre of ſilver will be thereby decompoſed, and a vitriol of ſilver obtained ſimilar to the former.

Although vitriolic acid engaged in any baſis, ſuch as fixed alkali, with which it has a ſtronger affinity than with ſilver, does nevertheleſs quit its baſis to combine with this metal, yet we may obſerve, that in theſe precipitations two decompoſitions and two new combinations are always effected, by means of a double affinity. We may therefore ſee the explanation of this caſe at the word AFFINITY.

Marine acid, whether engaged in any baſis, or diſengaged, produces in the ſolution of ſilver by nitrous acid the ſame effect as the vitriolic acid. It ſeparates from the nitrous acid the metal, with which it unites and forms a new compound, or a *marine ſalt with baſis of ſilver*, known to chemiſts by the name of *luna cornea*, or *corneous ſilver*. *See* LUNA CORNEA. It is called corneous, becauſe this ſilver, united with marine acid by expoſure to fire, may be melted; and may be coagulated by cold into a ſemi-tranſparent, ſemi-flexible maſs, like horn.

Luna cornea, although in a ſaline ſtate, is very little ſoluble by water. The precipitate which it forms is very apparent: it is compoſed of flocks, which adhere one to another, and form a kind of white curd, that floats in the liquor. By this appearance alone it may be diſtinguiſhed from vitriol of ſilver.

Theſe properties of a ſolution of ſilver, together with the facility with which it is rendered turbid by the preſence of the ſmalleſt quantity of vitriolic and marine acids, diſengaged or combined with any baſis, render it very convenient and much uſed for the examination of waters, and in other chemical operations, to aſcertain the preſence of theſe two acids, in whatever compound they may be contained.

Silver, as well as all metals, may be ſeparated from any acid by abſorbent earths, or by fixed and volatile alkalis; and when afterwards fuſed, it recovers its original properties. Silver, thus diſſolved, precipitated, and melted, is generally very pure. We may be certain that ſilver, which has been formed

 into

into luna cornea, and afterwards has been reduced, does not contain a particle of gold, platina, copper, iron, or other metallic ſubſtance ſoluble in aqua regia, and conſequently not ſeparable from nitrous acid by means of marine acid.

From what has been ſaid concerning theſe ſeveral decompoſitions of a ſolution of ſilver made by nitrous acid, we may infer that this combination may be decompoſed;

1. By the action of fire alone, which expels the nitrous acid.

2. By phlogiſton, which burns and deſtroys nitrous acid in the detonation of lunar nitre.

3. By precipitation with ſaline or earthy alkalis, which ſeize the nitrous acid, and leave the ſilver diſengaged in the ſtate of a precipitate.

4. By vitriolic acid, which ſeizes the ſilver, and leaves the nitrous acid diſengaged.

5. By marine acid, which has the ſame effect.

6. Laſtly, ſeveral metals, and eſpecially copper, having a ſtronger affinity than ſilver with nitrous acid, decompoſe alſo this ſolution of ſilver, by ſeizing the acid, and obliging the ſilver to ſeparate from it, which it does by precipitating it in its proper metallic ſtate. *See the words* PRECIPITATE *and* PRECIPITATION.

Sulphur diſſolves ſilver by fuſion, and forms with it a blackiſh maſs, which may be cut, and which has almoſt the color and conſiſtence of lead. It is called *ſulphurated ſilver*. This compound is a kind of artificial ore of ſilver. Some expert perſons are ſaid to be able to imitate very well by this mixture ſome natural ores of ſilver.

To make this combination, ſilver and ſulphur are laid alternately upon each other in ſeveral ſtrata in a crucible, which is to be heated by degrees till the whole be fuſed. Leſs heat is required for this fuſion than if the ſilver was alone, becauſe ſulphur facilitates the fuſion of this, as well as of all other metals difficultly fuſible, upon which it is capable of acting.

The ſulphur may be ſeparated from the ſilver by the mere action of the fire, continued during a certain time with acceſs of air. When ſulphurated ſilver is detonated with nitre, this ſeparation is very well and inſtantly made. As this metal is indeſtructible by all theſe agents, it is found to be unchanged by theſe operations.

Juncker relates, after Kunckel, that if ſulphur be diſſipated from ſulphurated ſilver by the action of fire; and if a volatile alkaline ſpirit of urine be poured upon this ſilver, a blue color is produced. He adds alſo, that this does not happen a ſecond time to the ſame ſilver, unleſs it be firſt cupelled with lead. This chemiſt concludes from thence, that this color proceeds from copper which the ſilver receives from the lead. *See Conſpectus Chymiæ, Tom.* I. *p.* 893.

Silver is found within the earth in different ſtates. A very ſmall quantity of it is in its natural and malleable ſtate, allayed with copper and gold; and is then called *virgin* or *native ſilver*: but ſilver is generally found in a mineral ſtate, that is, united and incorporated with heterogeneous matters, ſuch as other metallic ſubſtances, and the mineraliſing ſubſtances, namely, ſulphur and arſenic. It is ſeparated from all theſe matters by particular proceſſes practiſed both in eſſays and in ſmelting the ore in large quantities. *See* ORES *of* SILVER.

Silver

Silver is purified from the allay of other destructible metals by treating it with nitre, or with lead. The latter method is generally used by refiners, and is called *cupellation*, or *refining*. *See* REFINING.

All these operations are founded in general upon the destructibility of imperfect metals, and on the indestructibility of silver, which is a perfect metal: but as gold is an indestructible metal, all the purifications of silver, which are only effected by the destruction of metals allayed with it, are insufficient to separate it from gold. We must therefore have recourse to other operations for the separation of these two metals from each other. These operations, which are called by the general name of *parting*, are founded upon the property which silver has of being soluble by many menstrua which do not act upon gold. These menstrua are;

1. Nitrous acid, which dissolves silver without touching gold. By means of this acid, silver is generally parted from gold, and the operation is called *parting*, without any epithet to distinguish it from the others. *See* PARTING.

2. Marine acid, which being applied conveniently to a mixture of gold and silver, seizes this latter metal exclusively of the former. As this parting is performed by cementation, and as the marine acid must be highly concentrated, it is called concentrated parting. *See* PARTING (CONCENTRATED).

3. Lastly, sulphur, which unites also to silver without touching gold, furnishes a third method of separating these two metals. This is called *dry parting*, because it is made by fusion, which chemists call the *dry way*. *See* PARTING (DRY).

Silver is capable of being allayed with all metals, and forms with them different compounds, the properties of which may be seen under the word ALLAY.

According to Mr. Geoffroy's table of affinities, those of silver are first to lead, and then to copper; and Mr. Gellert's table mentions only gold.

DCXXIX. SIMILOR. This is a name given to an allay of red copper and zinc, made in the best proportions to imitate the color of gold. *See* COPPER, BRASS, *and* ZINC.

DCXXX. SMALT Is a blue glass composed of the calx of cobalt, vitrified and melted with some fritt of glass or crystal. Ground smalt is called *azure*, or *enamel blue*. *See* AZURE, COBALT, *and* ZAFFRE.

DCXXXI. SMELTING *of* ORES. We have shewn, under the articles *ores* and *pyrites*, the nature of the principal metallic minerals, and the substances of which they are composed. We have also explained, under the article *essay of ores*, the processes by which an exact analysis of these compound minerals may be made, and the nature and quantity of the contained metals may be known. In order to compleat what relates to this important subject, we shall describe in this article the principal operations by which are obtained "in the great," as it is called, or for commercial purposes, metals, sulphur, vitriols, and other useful substances contained in metallic minerals. What we shall say upon this subject will chiefly be extracted from a *Treatise on the Smelting of Ores, by Schlutter*, translated from the German into French by *M. Hellot*; because this, of all the modern works upon that subject, appears to be the most exact. We shall first describe the operations upon pyritous matters for the extraction of sulphur, vitriols, and alum; and afterwards the operations by which metallic

metallic substances are extracted from ores properly so called; from which also are occasionally obtained the same matters as from the pyrites. As the present article is only the sequel of the articles *ores*, *pyrites*, and *essays of ores*, it is evident that these articles ought to be read previously to this.

EXTRACTION *of* SULPHUR *from* PYRITES *and other* MINERALS.

In order to obtain sulphur from pyrites, this mineral ought to be exposed to a heat sufficient to sublime the sulphur, or to make it distill in vessels, which must be close, to prevent its burning.

Sulphur is extracted from pyrites at a work at *Schwartzemberg*, in *Saxony*, in the high country of the mines; and in *Bohemia*, at a place called *Alten-Sattel*.

The furnaces employed for this operation are oblong, like vaulted galleries; and in the vaulted roofs are made several openings. These are called *furnaces for extracting sulphur*. See PLATE II. *Fig 9*.

In these furnaces are placed earthen-ware tubes, filled with pyrites broken into pieces of the size of small nuts. Each of these tubes contains about fifty pounds of pyrites. They are placed in the furnace almost horizontally, and have scarcely more than an inch of descent. The ends, which come out of the furnace five or six inches, become gradually narrower. Within each tube is fixed a piece of baked earth, in form of a star, at the place where it begins to become narrower, in order to prevent the pyrites from falling out, or choaking the mouth of the tube. To each tube is fitted a receiver, covered with a leaden plate, pierced with a small hole to give air to the sulphur. The other end of the tube is exactly closed. A moderate fire is made with wood, and in eight hours the sulphur of the pyrites is found to have passed into the receivers.

The residuum of the pyrites, after the distillation, is drawn out at the large end, and fresh pyrites is put in its place. From this residuum, which is called *burnings of sulphur*, vitriol is extracted; as we shall presently relate.

The eleven tubes into which were put, at three several distillations, in all nine quintals, or 900 pounds of pyrites, yield from 100 to 150 pounds of crude sulphur, which is so impure as to require to be purified by a second distillation.

This purification of crude sulphur is also done in a furnace in form of a gallery, in which five iron cucurbits are arranged on each side. These cucurbits are placed in a sloping direction, and contain about eight quintals and a half of crude sulphur. To them are luted earthen tubes, so disposed as to answer the purpose of capitals. The nose of each of these tubes is inserted into an earthen pot, called the *fore-runner*. This pot has three openings; namely, that which receives the nose of the tube; a second smaller hole, which is left open to give air; and a third in its lower part, which is stopped with a wooden peg. See PLATE II. *Fig. 10*.

When the preparations are made, a fire is lighted about seven o'clock in the evening, and is a little abated as soon as the sulphur begins to distill. At three o'clock in the morning, the wooden pegs, which stop the lower holes of the fore-

fore-runners, are for the first time drawn out, and the sulphur flows out of each of them into an earthen pot with two handles placed below for its reception. In this distillation the fire must be moderated and prudently conducted; otherwise less sulphur would be obtained, and it also would be of a grey color, and not of the fine yellow which it ought to have when pure. The ordinary loss in the purification of eight quintals of crude sulphur is, at most, one quintal.

When all the sulphur has flowed out, and has cooled a little in the earthen pots, it is cast into moulds made of beech tree, which have been previously dipt in water, and set to drain. As soon as the sulphur is cooled in the moulds, they are opened, and the cylinders of sulphur are taken out and put up in casks. These are called *roll-brimstone*.

As sulphur is not only in pyrites, but also in most metallic minerals, it is evident that it might be obtained by works in the great from the different ores which contain much of it, and from which it must be separated previously to their fusion: but as sulphur is of little value, the trouble of collecting it from ores is seldom taken. Smelters are generally satisfied with freeing their ores from it, by exposing them to a fire sufficient to expell it. This operation is called *torrefaction*, or *roasting of ores*.

There are, however, ores which contain so much sulphur, that part of it is actually collected in the ordinary operation of roasting, without much trouble for that purpose. Such is the ore of *Ramelsberg*, in the country of *Hartz*.

This ore, which is of lead, containing silver, is partly very pure, and partly mixed with cupreous pyrites and sulphur; hence it is necessary to roast it.

The roasting is performed by laying alternate strata of ore and wood upon each other in an open field, taking care to diminish the size of the strata as they rise higher; so that the whole mass shall be a quadrangular pyramid truncated above, whose base is about thirty-one feet square. Below, some passages are left open, to give free entrance to the air; and the sides and top of the pyramid are covered over with small ore, to concentrate the heat and make it last longer. In the center of this pyramid there is a channel, which descends vertically from the top to the base When all is properly arranged, laddle-fulls of red-hot scoria from the smelting furnace are thrown down the channel, by which means the shrubs and wood, placed below for that purpose, are kindled, and the fire is from them communicated to all the wood of the pile, which continues burning till the third day. At that time the sulphur of the mineral becomes capable of burning spontaneously, and of continuing the fire after the wood is consumed.

When this roasting has been continued fifteen days, the mineral becomes greasy, that is, it is covered over with a kind of varnish: twenty or twenty-five holes, or hollows, are then made in the upper part of the pile, in which the sulphur is collected. From these cavities the sulphur is taken out thrice every day, and thrown into water. This sulphur is not pure, but crude, and is therefore sent to the manufacturers of sulphur to be purified in the manner above related. See PLATE II. *Fig.* 11. *and* 12.

As this ore of Ramelsberg is very sulphureous, the first roasting, which we are now describing, lasts three months; and during this time, if much rain

has

has not fallen, or if the operation has not failed by the pile falling down or cracking, by which the air has so much free access, that the sulphur is burnt and consumed, from ten to twenty quintals of crude sulphur are by this method collected.

The sulphur of this ore, like that of most others, was formerly neglected, till, in the year 1570, a person employed in the mines, called Christopher Sauder, discovered the method of collecting it, nearly as it is done at present.

Metallic minerals are not the only substances from which sulphur is extracted. This matter is diffused in the earth in such quantities, that the metals cannot absorb it all. Some sulphur is found quite pure, and in different forms, principally in the neighbourhood of volcanos, in caverns, and in mineral waters. Such are the opake kind called *virgin sulphur*, the transparent kind called *sulphur of Quito*, and the native flowers of sulphur, as those of the waters of Aix-la-Chapelle. It is also found mixed with different earths. Here we may observe, that all those kinds of sulphur which are not mineralised by metallic substances, are found near volcanos, or hot mineral waters, and consequently in places where nature seems to have formed great subterranean laboratories, in which sulphureous minerals may be analysed and decomposed, and the sulphur separated, in the manner in which it is done in small in our works and laboratories. However that be, certainly one of the best and most famous sulphur-mines in the world is that called *Solfatara*. The Abbé Nollet has published, in the Memoirs of the Academy, some interesting observations upon this subject, which we shall here abridge.

Near Puzzoli, in Italy, is that great and famous mine of sulphur and alum called at present *Solfatara*. It is a small oval plain, the greatest diameter of which is about 400 yards, raised about 300 yards above the level of the sea. It is surrounded by high hills and great rocks, which fall to pieces, and whose fragments form very steep banks. Almost all the ground is bare and white, like marle, and is every where sensibly warmer than the atmosphere in the greatest heat of summer; so that the feet of persons walking there are burnt through their shoes. It is impossible not to observe the sulphur there; for every where may be perceived by the smell a sulphureous vapor, which rises to a considerable height, and gives reason to believe that there is a subterraneous fire below, from which that vapor proceeds.

Near the middle of this field there is a kind of bason three or four feet lower than the rest of the plain, in which a sound may be perceived when a person walks on it, as if there were under his feet some great cavity, the roof of which was very thin. After that, the lake Agnano is perceived, whose waters seem to boil. These waters are indeed hot, but not so hot as boiling water. This kind of ebullition proceeds from vapors which rise from the bottom of the lake, which being set in motion by the action of subterraneous fires, have force enough to raise all that mass of water. Near this lake there are pits, not very deep, from which sulphureous vapors are exhaled. Persons who have the itch, come to these pits, and receive the vapors in order to be cured. Finally, there are some deeper excavations, whence a soft stone is procured which yields sulphur. From these cavities vapors exhale, and issue out with noise, and which are nothing else than sulphur subliming through the crevices. This sulphur adheres to the sides of the rocks, where it forms enormous masses: in calm

weather

weather, the vapors may be evidently ſeen to riſe 25 or 30 feet from the ſurface of the earth.

Theſe vapors, attaching themſelves to the ſides of rocks, form enormous groups of ſulphur, which ſometimes fall down by their own weight, and render theſe places of dangerous acceſs.

In entering the Solfatara, there are warehouſes and buildings erected for the refining of ſulphur.

Under a great ſhed, or hangar, ſupported by a wall behind, and open on the other three ſides, the ſulphur is procured by diſtillation from the ſoft ſtones we mentioned above. Theſe ſtones are dug from under ground; and thoſe which lie on the ſurface of the earth are neglected. Theſe laſt are, however, covered with a ſulphur ready formed, and of a yellow color: but the workmen ſay they have loſt their *ſtrength*, and that the ſulphur obtained from them is not of ſo good a quality as the ſulphur obtained from the ſtones which are dug out of the ground.

Theſe laſt mentioned ſtones are broken into lumps, and put into pots of earthen ware, containing each about twenty pints, Paris meaſure. The mouths of theſe pots are as wide as their bottoms; but their bellies, or middle parts, are wider. They are covered with a lid of the ſame earth, well luted, and are arranged in two parallel lines along two brick walls, which form the two ſides of a furnace. The pots are placed within theſe walls; ſo that the center of each pot is in the center of the thickneſs of the wall, and that one end of the pots overhangs the wall within, while the other end overhangs the wall without. In each furnace ten of theſe pots are placed; that is, five in each of the two walls which form the two ſides of the furnace. Betwixt theſe walls there is a ſpace of fifteen or eighteen inches; which ſpace is covered by a vault reſting on the two walls. The whole forms a furnace ſeven feet long, two feet and a half high, open at one end, and ſhut at the other, excepting a ſmall chimney, through which the ſmoke paſſes.

Each of theſe pots has a mouth in its upper part without the furnace, in order to admit a tube of eighteen lines in diameter and a foot in length, which communicates with another pot of the ſame ſize placed without the building, and pierced with a round hole in its baſe of fifteen or eighteen lines diameter. Laſtly, to each of theſe laſt mentioned pots there is a wooden tub placed below, in a bench made for that purpoſe.

Four or five of theſe furnaces are built under one hangar or ſhed. Fires are kindled in each of them at the ſame time; and they are thrown down after each diſtillation, either that the pots may be renewed, or that the reſiduums may be more eaſily taken out.

The fire being kindled in the furnace, heats the firſt pots containing the ſulphureous ſtones. The ſulphur riſes in fumes into the upper part of the pot, whence it paſſes through the pipe of communication into the external veſſel. There the vapors are condenſed, become liquid, and flow through the hole below into the tub, from which the ſulphur is eaſily turned out, becauſe the form of the veſſel is that of a truncated cone, whoſe narrower end is placed below, and becauſe the hoops of the tub are ſo faſtened that they may be occaſionally looſened. The maſs of ſulphur is then carried to the buildings mentioned before, where it is remelted for its purification, and caſt into rolls, ſuch as we receive it.

EXTRACTION *of* VITRIOL *from* PYRITES.

Sulphur is not the only substance procured from pyrites; for besides that, different kinds of vitriols and alum, according to the nature of the pyrites, are also extracted: so that pyrites may be considered as the ores of vitriols and alum as well as of sulphur.

These salts do not exist in the pyrites ready formed, as the sulphur does; but are, on the contrary, the products of the decomposition of pyrites, and are new combinations resulting from this decomposition. In the pale-yellow martial pyrites, this decomposition is effected without any other means than by exposure to moisture and air, and by the re-action of the sulphureous principle upon the iron which the pyrites contains, and with which the acid of the sulphur forms martial vitriol, as we may see under the article Pyrites. When the vitriol of this pyrites is to be extracted, this mineral is to be laid in a large heap three feet thick, and exposed to the air during three years, till it has entirely fallen into powder; and it is then to be stirred up every six months to accelerate the efflorescence. The rain-water, which has washed it, is to be conducted into caldrons, into which old iron is thrown to saturate the superfluous acid. After this succeeds the evaporation and crystallization.

It is not necessary that the pyrites should fall into efflorescence for the extraction of vitriol. The action of the fire which decomposes one part of the sulphur produces the same effect. Thus, in the works at Schartzemberg in Upper Saxony, the vitriol is extracted, by lixiviating the pyrites after the distillation of the sulphur, which is called in some works, as we have before said, the *burnings of sulphur*, and which are in this work called *sulphur-brands*. This operation consists in impregnating well the lixivium with vitriol, by pouring it upon fresh parcels of these sulphur-brands, which is called doubling the lixivium: then it is evaporated in a leaden caldron, called the *sulphur-caldron*; and afterwards it is crystallized in a wooden vessel. The sulphur-brands, from which vitriol has been extracted, are not thereby exhausted; but they are exposed to the open air for two years, and are then again lixiviated for the extraction of more vitriol.

Vitriol is also made at *Geyer*, in Upper Saxony. The difference betwixt the method employed there and at Schwartzemberg, is, that at Geyer the pyrites has not been used for the extraction of sulphur by distillation, but has been roasted fifteen days, and afterwards lixiviated. The lixivium is evaporated in leaden caldrons, and afterwards put in shallow tubs called coolers, where it deposites a yellow mud. The evaporation and depuration of this lixivium last twenty-four hours, and then the liquor is put into tubs to crystallize.

The pyrites, which has been roasted and lixiviated once at Geyer, is not thereby exhausted; but is made to undergo the same operation four or five times, by which it furnishes more vitriol. The yellow mud which is deposited from the lixivium is sold, as a coloring material, to painters, after it has been calcined to redness.

Nature furnishes a vitriol ready formed in some mineral earths, to obtain which vitriol, nothing but lixiviation is necessary. Such is that vitriol obtained at Cremnitz,

Cremnitz, where there is a rich ore of gold. The vitriol is there extracted merely for the purpose of preparing aqua fortis, which is necessary in the operation for parting the gold contained in that ore. In the neighbourhood of Cremnitz, a soft rock and clay are found, containing vitriol, and which furnish it by means of lixiviation.

To this kind of vitriol ready formed may be referred that obtained at Goslar by the lixiviation of a mineral earth, composed of particles of different ores, found in the galleries of the mine at Rammelsberg, of which we have already spoken. The workmen call this substance the *smoke of copper*. It requires lixiviation only to furnish vitriol. It is true, that by the wood-fires made in these galleries to calcine the rocks, the metallic matters may be disengaged, and a part of the sulphur burnt, the acid of which, mixing with the subterranean waters, dissolves all the metallic matters it meets, and forms all kinds of vitriols. Netherthelefs, some of these vitriolic waters, and even some crystallized vitriols, are found in these galleries, where no fire is ever made. The Germans call all these vitriols by the general name *Joekels*. Some vitriols are also found not crystallized, but forming various colored stones, which furnish vitriol by lixiviation. They are called *ink-stones*. What is called *misy* is a yellow, shining, vitriolic stone or earth, found in the same places.

To return to the substance called smoke of copper, whence the martial vitriol is extracted at Goslar; several lixiviums are made of it, by pouring the same water upon different parcels of it: it is then made to evaporate, to deposite its sediment, and to crystallize, as we have already said. The first water is called the *wild lie*. The several vessels employed at Goslar are named from their several uses, as the *washing tub*, *mud tub*, &c.

This substance remaining after the lixiviation of this smoke of copper, is a kind of ore not entirely deprived of metallic substances. The workmen call the finest part of it *small vitriol*, and the larger pieces they call *stones*, or *kernels of vitriol*. Both these are carried to the smelting-houses to be roasted and melted with the Rammelsberg ore, that the lead and silver, which they contain as well as that ore, may be extracted.

A white vitriol, whose basis is zinc, is also procured at Goslar from the same Rammelsberg ore. This vitriol was discovered in the year 1570 by the Duke Julian, who called it *alum of the mine*. At present it is known by the names, *white vitriol*, *vitriol of zinc*, *Goslar vitriol*

To make this vitriol, the ore of Rammelsberg, containing lead and silver, having been previously roasted for the obtaining of sulphur, as we have already described, undergoes the same operations which are practised for the preparation of martial vitriol, excepting the formation of large crystals, which is here purposely prevented, by liquefying the vitriol after it is formed in copper caldrons. This liquefaction is effected by means of the water retained in the crystallization of the vitriol. While the vitriol is liquefied, a part of the moisture is evaporated, and women employed in this work keep stirring it till it has acquired the requisite consistence. By this stirring, it is divided into very fine crystalline particles, and it acquires the whiteness of the finest sugar; a quality which makes it saleable, and which is procured by the means above related, and by carefully making it deposite the ferruginous matter with which these lixiviums are always impregnated.

As to the blue vitriol, or vitriol of copper, it is extracted from the cupreous pyrites, or even from sulphureous copper ores, by the operations already mentioned. Frequently the ferruginous pyrites and minerals also contain copper: and therefore the vitriol extracted from them is half martial and half cupreous, and is of a sea-green color.

EXTRACTION *of* ALUM *from* PYRITOUS SUBSTANCES *and from* ALUMINOUS EARTHS.

One part of the unmetallic earth which is always in pyrites, and in other metallic and sulphureous minerals, is sometimes of that kind of earths which are soluble in acids, and particularly of the nature of that earth which is the basis of alum.

When the pyrites contains some of this kind of earth, the acid of its sulphur being disengaged either by the efflorescence of the pyrites, or by its calcination and combustion, ought to unite itself as readily, and even more so, to this earth than to the metals contained in the same pyrites, and form a true alum: accordingly it so happens, and alum is extracted from pyrites or other sulphureous minerals containing this earth, by processes similar to those employed for the extraction of vitriols.

In England, a pyritous, slate-colored, sulphureous stone is found, from which alum is extracted by torrefaction and lixiviation; but to this lixivium a certain quantity of fossile alkali, dissolved in water, is generally added.

The Swedes have a shining pyrites of a golden color, and speckled with silvery spots, from which they extract sulphur, vitriol, and alum. Sulphur and vitriol are extracted from it by the methods we have described; and when the lixivium yields no more crystals of vitriol, an eighth part of putrefied urine and lixivium of woodashes is added, by which a martial earth is precipitated: the liquor being poured off, crystals of alum are obtained by evaporation.

Finally, it appears that in general, when alum is to be extracted from sulphureous and metallic minerals, fine and pure crystals cannot be without some difficulty obtained. It is almost always necessary to have recourse to some additions of alkaline matters, such as quicklime, and fixed or volatile alkaline salts.

These difficulties proceed partly from this, that different kinds of salts are formed at the same time by the decomposition of these minerals; and that these salts are crystallized by nearly the same degrees of evaporation and cold. hence a confusion of salts must necessarily follow: and hence we do not find many of the vitriols, extracted from such minerals, perfectly pure and free from alum, or from vitriolic salts with earthy bases similar to alum. The *salt of colcothar* and the *gilla vitrioli* are nothing else than these foreign salts. On the other hand, the alum which is extracted from metallic minerals contains almost always some vitriol, and particularly martial vitriol. (*k*)

(*k*) From Mr. Margraaf's experiments, an addition of some alkaline substance seems to be always necessary to the formation of large crystals of alum, however free the lixivium is from the mixture of vitriols or other salts. *See a note* (*c*) *subjoined to the article* ALUM (ROMAN).

But

But there are unmetallic earths and ftones which contain alum, or its materials, ready formed. Such is that earth whence alum is extracted at Solfatara. This mineral is an earth fimilar to marle in confiftence and color. It is gathered in the plain, and in the weftern part of the Solfatara. It is put into leaden caldrons two feet and a half in diameter, and as much in depth, till thefe veffels be three quarters full. The caldrons are funk fo as to be almoft level with the ground, under a great hangar or fhed, at a diftance of four hundred paces from the fulphur furnaces. Into each caldron water is poured till it rife three or four inches above the mineral. The heat of the ground in this place is fufficient to warm the matter, as it makes Mr. Reaumur's thermometer rife to $37\frac{1}{2}$ degrees above the freezing point. By this means, without the expence of wood, the faline part is feparated from the earthy, and is obtained in large cryftals.

Alum in this ftate is ftill mixed with many impurities, and is carried to the building at the entry of the Solfatara, where it is diffolved by hot water in a great ftone veffel in form of a funnel. The purification of alum may be made fo much more advantageoufly in this place, as no wood is neceffary, the natural heat of the place being fufficient for the procefs.

To this kind of natural alum may be referred that which is obtained merely by evaporation from fome mineral waters; and alfo the Roman alum which is obtained from a kind of free-ftone, although a calcination during twelve or fourteen hours, and an expofition to the air till it falls into efflorefcence be neceffary. This ftone is not pyritous, but rather of the marle kind: therefore its efflorefcence is probably nothing more than an extinction, and differs effentially from the efflorefcence of pyrites.

Such are the proceffes by which fulphur, vitriol, and alum are obtained from minerals containing thefe fubftances.

Thefe minerals contain a great quantity of vitriolic acid, which chemifts can feparate from them; and they are, as it were, the grand magazines where nature depofites this acid, which is always found combined, as we have feen, with fome fubftance or bafis.

SMELTING of ORES *in general.*

As ores confift of metallic matters combined with fulphur and arfenic, and are befides intermixed with earthy and ftony fubftances of all kinds, the intention of all the operations upon thefe compound bodies is to feparate thefe different fubftances from each other. This is effected by feveral operations founded on the known properties of thofe fubftances. We now proceed to give a general idea of thefe feveral operations.

Firft of all, the ore is to be feparated from the earths and ftones accidentally adherent to it; and when thefe foreign fubftances are in large maffes, and are not very intimately mixed in fmall particles with the ore, this feparation may be accomplifhed by mechanical means. This ought always to be the firft operation, unlefs the adherent fubftance be capable of ferving as a flux to the ore. If the unmetallic earths be intimately mixed with the ore, this muft neceffarily be broken and divided into fmall particles. This operation is performed by a machine

machine which moves pestles, called bocards, or stampers. After this operation, when the parts of the mineral are specifically heavier than those of the unmetallic earth or stone, these latter may be separated from the ore by washing in canals through which water flows. With regard to this washing of ores, it is necessary to observe that it cannot succeed but when the ore is sensibly heavier than the foreign matters. But the contrary happens frequently, as well because quartz and spar are naturally very ponderous, as because the metallic matter is proportionably so much lighter as it is combined with more sulphur.

When an ore happens to be of this kind, it is necessary to begin by roasting it, in order to deprive it of the greatest part of its sulphur.

It happens frequently that the pyritous matters accompanying the ore are so hard that they can scarcely be pounded. In this case it is necessary to roast it entirely, or partly, and to throw it red-hot into cold water; by which the stones are split, and rendered much more capable of being pulverised.

Thus it happens very frequently, that roasting is the first operation to which an ore is exposed.

When the substance of the ore is very fusible, this first operation may be dispensed with, and the matter may be immediately fused without any previous roasting, or at least with a very slight one. For, to effect this fusion, it is necessary that it retain a certain quantity of its sulphur, which, with the other fluxes added, serves to destroy or convert into scoria a considerable part of the stoney matter of the mineral, and to reduce the rest into a brittle substance which is called the *matt of lead*, or of *copper*, or other metal contained in the ore. This matt is therefore an intermediate matter betwixt the mineral and the metal; for the metal is there concentrated, and mixed with less useless matter than it was in the ore. But as this matt is always sulphureous, the metal which it contains cannot have its metallic properties. Therefore it must be roasted several times to evaporate the sulphur, before it is remelted, when the pure metal is required. This fusion of an ore not roasted, or but slightly roasted, is called *crude fusion*.

We may here observe upon the subject of washing and roasting of ores, that as arsenic is heavier than sulphur, and has nearly the weight of metals, the ores in which it prevails are generally very heavy, and consequently are susceptible of being washed, which is a great advantage. But on the other side, as arsenic is capable of volatilising, scorifying, and destroying many metals, these ores have disadvantages in the roasting and fusion, in both which considerable loss is caused by the arsenic. Some ores contain, besides arsenic, other volatile semi-metals, such as antimony and zinc. These are almost untractable, and are therefore neglected. They are called *mineræ rapaces*, rapacious ores.

When the metal has been freed as much as is possible from foreign matters by these preliminary operations, it is to be completely purified by fusions more or less frequently repeated; in which proper additions are made, either to absorb the rest of the sulphur and arsenic, or to complete the vitrification or scorification of the unmetallic stones and earth.

Lastly,

Laſtly, as ores frequently contain ſeveral different metals, theſe are to be ſeparated from each other by proceſſes ſuited to the properties of theſe metals, of which we ſhall ſpeak more particularly as we proceed in our examination of the ores of each metal. (*l*)

(*l*) To facilitate the extraction of metallic ſubſtances from the ores and minerals containing them, ſome operations previous to the fuſion or ſmelting of theſe ores and minerals are generally neceſſary. Theſe operations conſiſt of, 1. The *ſeparation* of the ores and metallic matters from the adhering unmetallic earths and ſtones, by hammers, and other mechanical inſtruments; and by waſhing with water. 2. Their *diviſion* or reduction into ſmaller parts by contuſion and trituration, that by another waſhing with water they may be more perfectly cleanſed from extraneous matters, and rendered fitter for the ſubſequent operations, calcination or roaſting, and fuſion. 3. *Roaſting* or *calcination*, the uſes of which operation are, to expel the volatile, uſeleſs, or noxious ſubſtances, as water, vitriolic acid, ſulphur, and arſenic; to render the ore more friable and fitter for the ſubſequent contuſion, and fuſion; and, laſtly, to calcine and deſtroy the viler metals; for inſtance, the iron of copper-ores, by means of the fire, and of the ſulphur and arſenic. Stones, as quartz, and flints, containing metallic veins or particles, are frequently made red hot, and then extinguiſhed in cold water, that they may be rendered ſufficiently friable and pulverable, to allow the ſeparation of the metallic particles.

Roaſting is unneceſſary for native metals; for ſome of the richer gold and ſilver-ores; for ſome lead-ores, the ſulphur of which may be ſeparated during the fuſion; and for moſt calciform ores, as theſe do not generally contain any ſulphur and arſenic.

In the roaſting of ores, the following attentions muſt be given, 1. To reduce the mineral previouſly into ſmall lumps, that the ſurface may be encreaſed; but they muſt not be ſo ſmall, nor placed ſo compactly, as to prevent the paſſage of the air and flame. 2. The larger pieces muſt be placed at the bottom of the pile, where the greateſt heat is. 3. The heat muſt be gradually applied, that the ſulphur may not be melted, which would greatly retard its expulſion; and that the ſpars, fluors, and ſtones, intermixed with the ore, may not crack, fly and be diſperſed. 4. The ores not thoroughly roaſted by one operation muſt be expoſed to a ſecond. 5. The fire may be encreaſed towards the end, that the noxious matters more ſtrongly adhering may be expelled. 6. Fuel which yields much flame, as wood and foſſil coals free from ſulphur, is ſaid to be preferable to charcoal or coaks. Sometimes cold water is thrown on the calcined ore at the end of the operation, while the ore is yet hot, to render it more friable.

No general rule can be given concerning the duration or degree of the fire, theſe being very various according to the difference of the ores. A roaſting during a few hours or days is ſufficient for many ores; while ſome, ſuch as the ore of Rammelſberg, require that it ſhould be continued during ſeveral months.

Schlutter enumerates five methods of roaſting ores. 1. By conſtructing a pile of ores and fuel placed in alternate ſtrata, in the open air, without any furnace. *See* PLATE II. *Fig.* 11. *and Fig.* 12. 2. By confining ſuch a pile within walls, but without a roof. 3. By placing the pile under a roof, without lateral walls. 4. By placing the pile in a furnace conſiſting of walls and a roof. 5. By roaſting the ore in a reverberatory furnace, in which it muſt be continually ſtirred with an iron-rod.

Several kinds of *fuſions of ores* may be diſtinguiſhed. 1. When a ſulphureous ore is mixed with much earthy matter, from which it cannot be eaſily ſeparated, by mechanical operations, it is frequently melted, in order to diſengage it from theſe earthy matters, and to concentrate its metallic contents. By this fuſion, ſome of the ſulphur is diſſipated, and the ore is reduced to a ſtate intermediate betwixt that of ore and of metal. It is then called a *matt* (*lapis ſulphureo-metallicus*), and is to be afterwards treated like a pure ore by the ſecond kind of fuſion, which is properly the *ſmelting*, or *extraction of the metal by fuſion*. 2. By this fuſion, or ſmelting, the metal is extracted from the ore previouſly prepared by the above operations, if theſe be neceſſary. The ores of ſome very fuſible metals, as of biſmuth, may be ſmelted by applying

OPERATIONS *on* ORES *of* NATIVE GOLD *and* SILVER, *by* WASHING *and by* MERCURY.

Earths and ſand are at firſt ſeparated by waſhing with water, by which operation the greateſt part of what is not gold, being lighter, is carried off. After this a ſecond waſhing is made with mercury, which having the property of uniting with gold, ſeizes this metal, amalgamates with it, and ſeparates it exactly from the earthy matters, with all which it can form no union.

applying a heat ſufficient only to melt the metals, which are thereby ſeparated from the adhering extraneous matters. This ſeparation of metals by fuſion, without the vitrification of extraneous matters, may be called *eliquation*. Generally, a compleat fuſion of the ore and vitrification of the earthy matters are neceſſary for the perfect ſeparation of the contained metals. By this method, metals are obtained from their ores, ſometimes pure, and ſometimes mixed with other metallic ſubſtances, from which they muſt be afterwards ſeparated; as we ſhall ſee, when we treat of the extraction of particular metals. To procure this ſeparation of metals from ores, theſe muſt be ſo thinly liquefied, that the ſmall metallic particles may diſengage themſelves from the ſcoria; but it muſt not be ſo thin as to allow the metal to precipitate before it be perfectly diſengaged from any adhering extraneous matter, or to pervade and deſtroy the containing veſſels and furnace. Some ores are ſufficiently fuſible; but others require certain additions called *fluxes*, to promote their fuſion, and the vitrification of their unmetallic parts; and alſo to render the ſcoria ſufficiently thin to allow the ſeparation of the metallic particles.

Different fluxes are ſuitable to different ores, according to the quality of the ore; and of the matrix, or ſtone adherent to it.

The matrixes of two different ores of the ſame metal frequently ſerve as fluxes to each other; as, for inſtance, an argillaceous matrix with one that is calcareous: theſe two earths being diſpoſed to vitrification when mixed, tho' each of them is ſingly unfuſible. For this reaſon, two or more different ores to be ſmelted are frequently mixed together.

The ores alſo of different metals require different fluxes. Thus calcareous earth is found to be beſt ſuited to iron-ores, and ſpars and ſcoria to fuſible ores of copper.

The fluxes moſt frequently employed in the ſmelting of ores are, calcareous earth, fluors or vitreous ſpars, quartz and ſand, fuſible ſtones, as ſlates, baſaltes, the ſeveral kinds of ſcoria, and pyrites.

Calcareous earth is uſed to facilitate the fuſion of ores of iron, and of ſome of the poorer ores of copper, and, in general, of ores mixed with argillaceous earths, or with feltſpar. This earth has been ſometimes added with a view of ſeparating the ſulphur, to which it very readily unites: but by this union, the ſulphur is detained, and a hepar is formed, which readily diſſolves iron and other metals, and ſo firmly adheres to them, that they cannot be ſeparated without more difficulty than they could from the original ore. This addition is therefore not to be made till the ſulphur be previouſly well expelled.

Fluors or *fuſible ſpars* facilitate the fuſion of moſt metallic minerals, and alſo of calcareous, and argillaceous earths, of ſteatites, aſbeſtus, and of ſome other unfuſible ſtones, but not of ſiliceous earths without a mixture of calcareous earth.

Quartz is ſometimes added in the fuſion of ferruginous copper ores, the uſe of which is ſaid chiefly to be, to enable the ore to receive a greater heat, and to give a more perfect vitrification to the ferruginous ſcoria.

The *fuſible ſtones*, as *ſlates*, *baſaltes*, are ſo tenacious and thick when fuſed, that they cannot be conſidered properly as fluxes, but as matters added to leſſen the too great liquidity of ſome very fuſible minerals.

The *ſcoria* obtained in the fuſion of an ore is frequently uſeful to facilitate the fuſion of an ore of the ſame metal, and ſometimes even of ores of other metals.

Sulphurated pyrites greatly promotes the fuſibility of the ſcoria of metals, from the ſulphur it contains. It is chiefly added to difficultly

The mercury thus charged with gold is pressed through shamoy leather, and the gold is retained united with a part of the mercury, from which it may be easily disengaged by exposure to a proper degree of heat, which dissipates and evaporates the mercury, while the gold, being fixed, remains.

This is the foundation of all the operations by which gold is obtained from the rich mines of Peru belonging to the Spaniards. These operations consist in washings, triturations, and amalgams in the great by help of machines. We shall not enter into these details, because they rather belong to mechanics than to chemistry. They who are desirous to know them, may consult a work written by Alonzo Barba on this subject.

The ores of native silver are much rarer and less abundant than those of gold. But if any of this kind were found sufficiently rich, they might be treated with mercury exactly in the same manner as the ores of native gold. (*m*)

difficultly fusible copper-ores, to form the sulphureous compounds called *matts*, that the ores thus brought into fusion may be separated from the adhering earthy matters, and that the ferruginous matter contained in them may be destroyed, during the subsequent calcination and fusion, by means of the sulphur.

As in the ores called *calciform*, the metallic matter exists in a calcined state; and as calcination reduces the metals of mineralised ores (excepting the perfect metals) to that state also; therefore all calciform and calcined ores require the addition of some *inflammable substance*, to furnish them with the phlogiston necessary for their reduction to a metallic state. In great works, the charcoal or other fuel used to maintain the fire produces also this effect.

Metals are sometimes added in the fusion of ores of other more valuable metals, to absorb from these sulphur or arsenic. Thus iron is added to sulphurated, cupreous, and silver ores. Metals are also added in the fusion of ores of other more valuable metals, to unite with and collect the small particles of these dispersed through much earthy matter, and thus to assist their precipitation. With these intentions, lead is frequently added to ores and minerals containing gold, silver, or copper.

Ores of metals are also sometimes added to assist the precipitation of more valuable metals. Thus antimony is frequently added to assist the precipitation of gold intermixed with other metallic matters. See *purification of gold by antimony*. Thus far of smelting of ores in general.

(*m*) Gold is frequently contained in the ores of other metals, either in a native or mineralised state, and in sands, especially those which are black and ferruginous. *See* Ores *of* Gold.

If *gold be contained in ores of other metals*, these metals together with the gold may be first extracted by the ordinary processes for smelting these ores; and the gold may be then separated from the metallic mass thus obtained, by mixing and fusing this mass with a quantity of lead, and by the process of cupellation, described in the articles Essay *of the* Value *of* Silver, *and* Refining. Generally, the operations for obtaining gold from ores of imperfect metals are precisely the same as those for obtaining silver, to which therefore we refer. Most frequently a quantity of silver also is contained in these ores; and in this case the perfect metal obtained by cupellation is an allay of gold and silver, which must be afterwards separated by the processes called *parting*. *See* Parting.

Many trials have been made to procure the small quantity of gold contained in the *ferruginous sands*, at a moderate expence (*See* Ores *of* Gold); but as no work of this kind is now established, we may presume they have not been successful. The best essays of this kind have been made, according to Schlutter, in the following manner.

The sand is to be made red-hot, and extinguished in cold water four times, by which its color is changed from the original yellow, red, or black, to a reddish brown. It is observed to emit, during the first and second calcinations, an arsenical smell; and this smell may be produced again in the following calcinations by adding some inflammable matter. Let an ounce of the calcined sand be mixed with two ounces of

 granulated

SMELTING *of* ORES *of* SILVER.

As ſilver, even in its proper ores, is always allayed with ſome other metals from which it is intended to be ſeparated, after that the ſilver ore has been well roaſted, it muſt be mixed with a greater or leſs quantity of lead previous to its fuſion.

Lead has the ſame effect in fuſion of gold and ſilver as mercury has upon theſe metals by its natural fluidity; that is to ſay, it unites with them, and ſeparates them from unmetallic matters, which, being lighter, riſe always to the ſurface. But lead has the further advantage of procuring, by its own vitrification, that of all metallic ſubſtances, excepting gold and ſilver. Hence it follows, that when gold and ſilver are obtained by means of mercury, they ſtill remain allayed with other metallic ſubſtances; whereas when they are obtained by fuſion and ſcorification with lead, they are then pure, and are not allayed with any metals but with each other.

In proportion as the lead, which has been united to the gold and ſilver of the ore, is ſcorified by the action of the fire, and promotes the ſcorification of the other metallic matters, it ſeparates the perfect metals, and carries with it all the others to the ſurface. There it meets the unmetallic ſubſtances, which it likewiſe vitrifies, and which it changes into a perfect ſcoria, fluid, and ſuch as a ſcoria ought to be to admit all the perfect metal contained in it to precipitate.

When all heterogeneous matters have been thus diſengaged by ſcorification with lead, the perfect metals, to which ſome lead ſtill remains united, are to be further purified by the ordinary operation of the cupel.

The common rule for the fuſion and ſcorification of ſilver ore with lead, is to add to the ore a quantity of lead ſo much greater as there is more matter to be ſcorified, and as theſe matters are more refractory and of more difficult fuſion. Silver ores, or thoſe treated as ſuch, are often rendered refractory by ferruginous

granulated lead, and one ounce of black flux, and put into a Heſſian crucible, with half an ounce of decrepitated ſea-ſalt upon the ſurface of the mixture. The crucible is to be placed in a good blaſt furnace, and a ſtrong fire is to be excited. The matter contained in the crucible is to be frequently ſtirred with an iron-rod, and the heat is to be continued till the ſcoria is thin and perfectly fuſed. When the crucible is broken, a regulus of lead will be found, containing the gold and ſilver of the ſand. By this method Mr. Leberecht obtained, in eleven eſſays, from 840 to 844 grains of perfect metal from a quintal of ſand. Of the perfect metal obtained, from a fourth to a third part was gold. Some parcels of ſand have yielded more than a thouſand grains, and ſome not more than 350 grains per quintal. Inſtead of the granulated lead, and the black flux, which is too expenſive for great operations, ſome have added, to an ounce of the ſand, two ounces of litharge and a little powder of charcoal, by which they have obtained the ſame quantity of perfect metal. The ſcoria in theſe eſſays has been always found to contain ſome perfect metal.

The Hungarian copper ores, from which gold and ſilver are profitably extracted, contain a leſs quantity of theſe perfect metals than many ferruginous ſands. But they may be formed into a matt, by fuſion with pyrites, of which treatment the ſands are incapable. From this matt, the gold and ſilver, along with the copper of the ore, may be precipitated, and ſeparated from the ſulphur of the pyrites, by addition of iron, which being more diſpoſed than the other metals to unite with ſulphur, diſengages theſe metals, and allows them to precipitate.

earths,

earths, pyritous matters, or cobalts, containing always a confiderable quantity of an earth which is unmetallic, very fubtle, and very refractory, and which renders a confiderable augmentation of the quantity of lead neceffary.

The quantity of lead which is commonly added to fufible filver-ores, that do not contain lead, is eight times the quantity of the ore. But when the ore is refractory, it is neceffary to add twelve times the quantity of lead, and even more; alfo glafs of lead, and fluxes, fuch as the white and black fluxes; to which however borax and powder of charcoal are preferable, on account of the liver of fulphur formed by thefe alkaline fluxes.

It is neceffary to obferve, that faline fluxes are only ufed in fmall operations, on account of their dearnefs. To thefe are fubftituted, in the great operations, of which we now treat, fandiver, fufible fcoria, and other matters of little value.

The greateft part of the filver now employed in commerce is not obtained from the proper ores of filver, which are very fcarce, but from lead, and even copper-ores, which are more or lefs rich in filver. To give an idea of the manner of treating thefe kinds of ores, from which filver is extracted in the great works, we fhall briefly defcribe here, after Schlutter, the fmelting of the ore of Rammelfberg, which contains, as we have already faid, feveral different kinds of metals, but particularly lead and filver.

When this mineral has been difengaged from its fulphur as much as poffible, by three very long roaftings, it is melted in the Lower Hartz in Saxony, in a particular kind of furnace, called a furnace for fmelting upon a hollow or *caffe*. *See* PLATE II. *Fig.* 13. The mafonry of this furnace is compofed of large, thick flates, capable of fuftaining great heat, and cemented together by clay. The interior part of the furnace is three feet and a half long, and two feet broad at the back part, and one foot only in the front. Its height is nine feet eight inches. It has a foundation of mafonry in the ground; and, in this foundation channels are made for the evaporation of the moifture. Thefe channels are covered over with ftones called *covering ftones*. The hollow or caffe, which is made above thefe, is formed of bricks, upon which are placed, firft, a bed of clay; then a bed of fmall ore and fifted vitriols; and, laftly, a bed of charcoal-powder beat down, called *light brafque*. The anterior wall of the furnace is thinner than the others, and is called the *chemife*. The back wall, which is pierced to give paffage to the pipes of two large wooden bellows, is called the middle wall. When the furnace is thus prepared, charcoal is thrown into the hollow, or caffe; which being kindled, the fire is to be continued during three hours, before the matters to be fufed are added. Then thefe matters are thrown in, which are not the pure ore, but a mixture of feveral fubftances, all of which are fomewhat profitable. The quantity of thefe matters is fufficient for one day's work; that is for a fufion of eighteen hours; and it confifts of; 1. Twelve fchorbens or meafures of well roafted Rammelfberg ore; (the fchorben is a meafure whofe contents are two feet five inches long, one foot feven inches broad, and a little more than a foot deep: It is equal to 32 quintals of that country, Cologn weight, at 123 pounds each quintal). 2. Six meafures of fcoria produced by the fmelting of the ore of Upper Hartz, which is refractory, and what workmen call *cold*. 3. Two meafures of *knobben*, which is an impure fcoria containing fome lead and filver,

 which

which has been formerly thrown away as uſeleſs, and is now collected by women and children. Beſides theſe, other matters are added, containing lead and ſilver, as the teſts employed in refining, the droſs of lead, impure litharge, and any rubbiſh containing metal, which was left in the furnace after the foregoing fuſion. All theſe matters being mixed together are thrown into the furnace: And to each meaſure of this mixture a meaſure of charcoal is added. The fuſion is then begun by help of bellows; and as it proceeds, the lead falls through the light braſque or charcoal bed, into the hollow, or caſſe, where it is preſerved from burning under the powder of charcoal. The ſcoria, on the other hand, being lighter and leſs fluid, is ſkimmed off from time to time by means of laddles, that it may not prevent the reſt of the lead from falling down into the hollow. Thus, while the fuſion laſts, freſh matters and freſh charcoal are alternately added, till the whole quantity intended for one fuſion, or, as they call it, one *day*, be thrown in.

There are ſeveral eſſential things to be remarked in this operation, which is very well contrived. Firſt, the mixture of matters from which a little lead and ſilver is procured, which would otherwiſe be loſt; and which have alſo this advantage, that they retard the fuſion of the Rammelſberg ore, which, however well roaſted it has been, retains always enough of the ſulphur and iron of the pyrites mixed with it, to render it too fuſible or too fluid, ſo that without the addition of thoſe matters, nothing would be obtained but a matt. It is even neceſſary, notwithſtanding theſe additions, not to haſten the fuſion too much, but to give time for the ore to mix with the other matters, elſe it would melt and flow of itſelf before the reſt. Secondly, the fuſion of the ore through charcoal, which is practiſed in moſt ſmelting-houſes, and for almoſt all ores, is an excellent method, the principal advantage of which is the ſaving of fuel. The action of the burning charcoal directed immediately upon the mineral, at the ſame time that it melts it more readily and efficaciouſly, alſo ſupplies it with the phlogiſton neceſſary to bring it to a perfect ſtate.

We mentioned, when treating of vitriols obtained from the Rammelſberg ore after its firſt roaſting, that a *white vitriol* was alſo obtained, and prepared at *Goſlar*, whoſe baſis was *zinc:* which proves that this ore contains alſo a certain quantity of this ſemi-metal. As this ore is ſmelted in a country where the art is well underſtood of extracting every thing which a mineral contains, ſo in this fuſion *zinc* and *cadmia* are obtained in the following manner. When the furnace is prepared for the fuſion, it is neceſſary to cloſe it up in the fore-part, before the fuſion is begun.

" Firſt of all, a gritt-ſtone is to be placed, ſupported at the height of three " inches. This ſtone is as long as the furnace is broad, and the height of it " is level with the hole where the bellows pipe enters. It is faſtened on each ſide " of the furnace, externally and internally, with clay. Upon this ſtone a kind " of receptacle, or, as it is called, the *ſeat of the zinc*, is made in the following " manner. A flat, ſlaty ſtone is choſen, likewiſe as long as the furnace is " broad, and eight inches in breadth. This is placed on the gritt-ſtone above- " mentioned, in ſuch a manner, that it inclines conſiderably towards the front " of the furnace, and that its bottom touches cloſely the gritt-ſtone. It is " faſtened with clay, which is alſo laid upon the ſeat of the zinc. Upon this ſeat, " which is to receive the zinc, two round pieces of charcoal are placed, and upon

" theſe

" these a ſtone, called the *zinc ſtone*, reſts, which is about a foot and a half " in length, and cloſes one part of the front of the furnace. This ſtone alſo " is faſtened on each of its ſides with clay. Clay is likewiſe put under the " ſtone betwixt the two pieces of charcoal, which hinder it from touch- " ing the ſeat of the zinc. The under part of this ſtone is but ſlightly luted, " that the workmen may make an opening for the zinc to flow out. Thus " is made the ſeat or receptacle of the zinc to detain this metallic ſubſtance, " which would otherwiſe fall into the hotteſt part of the fire, called by the " workmen the melting place, and would be there burnt: whereas it is " collected upon this receptacle during the fuſion, where it is ſheltered from " the action of the bellows, and conſequently from too great heat.

" When all the matter to be fuſed in one day is put into the furnace, the " blaſt of air is continued till that matter has ſunk down. When it is half way " down the furnace, they draw out the ſcoria, that more of the ore and other " matters may be expoſed to the greateſt heat. As ſoon as the ſcoria is cooled " and fixed a little, two ſhovel-fulls of ſmall wet ſcoria or ſand is thrown cloſe " to the furnace, and beat down with the ſhovel; then the workmen open " the ſeat or receptacle of zinc, and ſtrike upon the zinc-ſtone to make the " ſemi-metal flow out. As ſoon as the pureſt part of it has flowed out, it " is ſprinkled with water and carried away. Then the workmen ſeparate entirely " the zinc-ſtone from the wall of the furnace, and they continue to give it little " ſtrokes, that the ſmall particles of zinc diſperſed among the charcoal may " fall down. This being done, the ſtone is removed, and the zinc is " ſeparated from the charcoal by an iron inſtrument, is cleaned, and remelted " along with the zinc that flowed out at firſt, and is caſt into round cakes. " The reaſon why the zinc is withdrawn before the bellows ceaſe to blow, is, " that if it was left till the charcoal on the ſeat or receptacle was conſumed, it " would be moſtly burnt, and little would be obtained. Thus after the zinc " is withdrawn, the fuſion is finiſhed by blowing the bellows till the end."

Thus the zinc is ſeparated from the ore of Rammelſberg, and is not confounded in the hollow or caſſe with the lead and ſilver, becauſe being a volatile ſemi-metal, it cannot ſupport the activity of the fire without riſing into vapors, which are condenſed in the place leaſt hot, that is to ſay, upon the ſtones expreſsly prepared for that purpoſe, and which being much thinner than the other walls of the furnace, are continually cooled by the external air.

It is alſo in this furnace, and after the fuſion of the Rammelſberg ore, that the *cadmia of zinc*, or the *cadmia of furnaces*, is obtained. This ore is compoſed of ſulphureous and ferruginous pyrites, of true lead ore containing ſilver, and a very hard and compact matter of a dark browniſh-grey color, which is probably a lapis calaminaris, or an ore of zinc. Theſe ſeveral matters of the Rammelſberg ore are not ſeparated from each other, either for the roaſting or for the fuſion. Thus there is zinc in all the parts of the roaſted ore, and much more of it would be obtained, if it was not ſo eaſily inflammable. All the zinc which is obtained is preſerved from burning by falling, while in fuſion, behind the chemiſe or forepart of the furnace, which is, as has been ſaid, a kind of ſchiſtus or ſlate, called by the workmen *ſteel-ſtone*: But the part of this ſemi-metal which falls in the middle of the furnace, near the middle wall, on

or towards the sides, being exposed to the greatest heat of the fire, is there burnt; and its smoke or flowers attaching itself on all sides to the walls of the furnace, undergo there a semi-fusion, which renders this matter so hard and so thick that it must be taken away after every fourth fusion, or, at most, after every sixth fusion. That which is found attached to the highest part of the furnace is the best and purest. The rest is altered by a mixture of a portion of lead which it has carried up with it, and which from its great weight and fixity has hindered the zinc from rising so high as it would have done alone. Therefore with this kind of impure cadmia ductile brass cannot be made.

Almost all the zinc we have, as well as the cadmia of the furnaces, is obtained from the Rammelsberg ore, by the process described, and consequently is not the produce of a pure ore of zinc, or lapis calaminaris, which is never fused for that purpose. Before Mr. Margraaf, although it was well known that this ore contained zinc, and that it was employed for the making of brass, a convenient process for extracting zinc from it was not known, because when treated by fusion with fluxes, like other ores, it does not yield any zinc; which proceeds partly from the refractory quality of the earth contained in the calamine, that cannot be fused without a very violent fire; and also from the volatility and combustibility of the zinc, which for this reason cannot be collected at the bottom of a crucible, as a regulus under a scoria, like most metals.

M Margraaf has remedied these inconveniences by distilling lapis calaminaris, mixed with charcoal, in a retort, to which is joined a receiver containing some water, and consequently in close vessels, where the zinc by the help of a very strong fire indeed, is sublimed in its metallic form without burning. He also by the same method reduced into zinc the *flowers of zinc*, or *pompholix*, *cadmia of the furnaces*, *tutty*, which is also a kind of cadmia; in a word, all matters capable of producing zinc by combination with phlogiston. But it is evident that such operations as these are rather fit to supply proofs for chemical theory, than to be put in practice for works in great (*n*). M. Margraaf has observed, that the zinc which he obtained by this process was less brittle than what is obtained from the fusion of ores; which may proceed from its greater purity, or from its better combination with phlogiston.

After this digression which we have now made concerning the operation in the great, by which zinc and cadmia are obtained, and which we could not insert elsewhere, because of the necessary relation it has with the smelting of the Rammelsberg ore, we proceed to the other operations of the same ore, that is to say, to the *finery*, by which the silver is separated from the lead, which are mixed together, forming what is called the *work*.

(*n*) Zinc is obtained not only in the method used at Goslar above-described, but is also extracted in great works from lapis calaminaris and calcined blend, by a distillation similar to that by which Mr Margraaf has essayed ores of zinc. The first work of that kind was erected in Sweden by Mr. Von Swab, in the year 1738. The ore employed was a kind of blend; this ore, when calcined, powdered, and mixed with charcoal, was put into iron or stone retorts, and the zinc was obtained by distillation. In Bristol a work is established in which zinc is obtained by a distillation *by descent*. See a section and description of the furnace and apparatus employed. Plate II. *Fig.* 22. and *explanation*.

This

This operation differs from the fining of essay, or in small, principally in this circumstance, that in the latter method of fining, all the litharge is absorbed into the cupel, whereas in the former method the greatest part of this litharge is withdrawn.

The fining in great of the work of Rammelsberg is performed in a furnace called a *reverberatory furnace*. This furnace is so constructed that the flame of wood burning in a cavity called the fire-place, is determined by a current of air (which is introduced through the ash-hole, and which goes out at an opening on one side of that part of the furnace where the work, that is the lead and silver are) to circulate above, and to give the convenient degree of heat, when the fire is properly managed. In this furnace a great cupel, called a *test*, is disposed. This test is made of the ashes of beech-wood, well lixiviated in the usual manner. In some foundaries different matters are added, as sand, spar, calcined gypsum, quicklime, clay. When the test is well prepared and dried, all the work is put at once upon the cold test, to the quantity of sixty-four quintals for one operation. Then the fire is lighted in the fire-place with faggots, but the fusion is not urged too fast; 1. That the test may have time to dry: 2. Because the work of the Rammelsberg ore is altered by the mixture of several metallic matters, which it is proper to separate from it, otherwise they would spoil the litharge and the lead procured from it. These metallic matters are, copper, iron, zinc, and matt. As these heterogeneous substances are hard and refractory, they do not melt so soon as the *work*, that is, as the lead and silver; and when the work is melted, they swim upon its surface like a skin, which is to be taken off. These impurities are called the *scum*, or the *first-waste*. What remains forms a second scum, which appears when the work is at its greatest degree of heat, but before the litharge begins to form itself. It is a scoria which is to be carefully taken off. It is called the *second waste*.

When the operation is at this point, it is continued by the help of bellows, the wind of which is directed, not upon the wood or fuel, but upon the very surface of the metal, by means of iron plates put for that purpose before the blast-hole, which are called *papillons*. This blast does not so much encrease the intensity of the fire, as it facilitates the combustion of the lead, and throws the litharge that is not imbibed by the test towards a channel, called the *litharge way*, through which it flows. The litharge becomes fixed out of the furnace: the matter which is found in the middle of the largest pieces, and which amounts to about a half or a third of the whole, is friable, and falls into powder like sand. This is put into barrels containing each five quintals of it, and is called saleable litharge, because it is sold in that state. The other part which remains solid is called *cold litharge*, and is again melted and reduced into lead. The fusion is called *cold fusion*, and the lead obtained from it, *cold lead*, which is good and saleable when the *work* has been well cleared from the heterogeneous matters mentioned above. The tests and cupels impregnated with litharge are added in the fusion of the ore, as we have already related.

When two thirds, or nearly that quantity, of the lead are converted into litharge, no more of it is formed. The silver then appears covered with a white

white skin, which the finers call *lightening*, and the metal, *lightened* or *fined silver*.

The silver obtained by this process of fining is not yet altogether pure. It still contains some lead, frequently to the quantity of four drams in each marc, or eight ounces. It is delivered to the workmen, who compleat its purification by the ordinary method. This last operation is the *refining*, and the workmen employed to do it are called *refiners*. A fining of sixty four quintals of *work*, yields from eight to ten marcs of fined silver, and from 35 to 40 quintals of litharge; that is, from 12 to 18 of saleable litharge, from 22 to 23 of cold litharge, from 20 to 22 quintals of impregnated test, and from six to seven quintals of lead-dross. The operation lasts from 16 to 18 hours. (*o*)

(*o*) Ores containing silver may be divided into four kinds; 1. *Pure*, or those which are not much compounded with other metals. 2. *Galenical*, in which the silver is mixed with much *galena* or ore of lead mineralised by sulphur. 3. *Pyritous*, in which the silver is mixed with the martial pyrites. 4. *Cupreous*; in which the silver is contained in copper-ores. To extract the silver from these several kinds of ores, different operations are necessary.

Native silver is separated from its adhering earths and stones by amalgamation with mercury, in the manner directed for the separation of gold; or by fusion with lead, from which it may be afterwards separated by cupellation.

Pure ores seldom require a previous calcination, but, when bruised and cleansed from extraneous matters, may be fused directly, and incorporated with a quantity of lead; unless they contain a large proportion of sulphur and arsenic; in which case a calcination may be useful. The lead employed must be in a calcined or vitrified state, which, being mixed with the ore, and gradually reduced by the phlogiston of the charcoal added to it, may be more effectually united with the silver of the ore, than if lead itself had been added, which would too quickly precipitate to the bottom of the containing vessel or furnace. The silver is to be afterwards separated from the lead by cupellation.

Galenical ores, especially those in which pyrites is intermixed, require a calcination, which ought to be performed in an oven, or reverberatory furnace. They are then to be fused together with some inflammable matter, as charcoal, by which the lead is revived, and, together with the silver, is precipitated.

Pyritous ores must be first melted, so as to form a matt. If the sulphur is not sufficient for this kind of fusion, more sulphurated pyrites may be added. This matt contains, besides silver and sulphur, also various metals, as lead, iron, and sometimes cobalt. The matt must be exposed to repeated calcinations till the sulphur is dissipated. By these calcinations most of the iron is destroyed. The calcined matt is to be fused with litharge, and the silver incorporated with the revived lead; from which, and from the other imperfect metals with which it may be mixed, it must afterwards be separated by cupellation. *See* REFINING.

The silver contained in *cupreous ores* may be obtained, either, 1. By separating it from the copper itself, after this has been extracted along with the silver, in the usual manner, from the ore; or, 2. By precipitating it immediately, from the other matters of the ore.

1. It may be separated from the copper by two methods. One of these is by adding lead, and scorifying the imperfect metals. By this method much of the copper would be destroyed, and it is therefore not to be used unless the quantity of silver relatively to the copper be considerable. Another method by which silver may be separated from copper is, by *eliquation*; that is, by mixing the mass of copper and silver with a quantity of lead, and applying such a heat as shall be just sufficient to make the lead eliquate from the copper, together with the silver, which being more strongly disposed to unite with the lead than with the copper, is thus incorporated with the former metal, and separated

SMELTING *of* ORES *of* COPPER.

The ſmelting in great of copper ores, and even of ſeveral ores of ſilver and lead, excepting that of Rammelſberg, is performed in furnaces not eſſentially different from that already deſcribed; but in this reſpect only, that the ſcoria and metal are not drawn out of the furnace, but flow ſpontaneouſly, as ſoon as they are melted, into *receiving baſons*, where the metal is freed from the ſcoria. Theſe furnaces are generally called *pierced furnaces*.

Inſtead of a light braſque, or bed of charcoal-powder, under which the metal lies hid, the bottom of theſe furnaces is covered with a baſon compoſed of heavy braſque, which is a mixture of charcoal-powder and clay. In the front of the furnace, and at the bottom of the chemiſe, there is a hole, called the *eye*, through which the melted matter flows, and runs along a trench or furrow, called the *trace*, into one or more *receiving baſons*, made of earth, ſcoria, ſand, &c. There the metal is ſeparated from the ſcoria, by making it flow from theſe baſons into another lateral one. Theſe furnaces are alſo called *crooked furnaces*.

Different names are given to them according to ſome difference in their conſtruction. For inſtance, thoſe which have two *eyes*, and two *traces*, through which the melted matter flows alternately into two baſons, are called *ſpectacle-furnaces*. Their greater or leſs height gives occaſion alſo to the diſtinction of *high furnaces*, and *middle furnaces*.

The high furnaces are of modern invention. They were firſt introduced at Mansfeldt in the year 1727, and they are now uſed in almoſt all countries where ores are ſmelted, as in Saxony, Bohemia, Hungary, &c. Their chief advantage conſiſts in ſimplifying and diminiſhing the labor. This advantage is effected by the great height of the furnace, which allows the ore to remain there a long time before it falls down into the hotteſt part of the fire, and is melted. Conſequently, it ſuffers ſucceſſively different degrees of heat, and, before it is melted, it undergoes a roaſting which coſts nothing; therefore the high furnaces

rated from the latter. *See the article* Eliquation.

2. Silver may alſo be extracted from theſe cupreous ores by *precipitation*. For this purpoſe let the ore, previouſly bruiſed and cleanſed, be formed into a matt, that the earthy matters may be well ſeparated. Let the matt be then fuſed with a ſtrong heat; and when the ſcoria has been removed, and the heat is diminiſhed, add to it ſome clean galena, litharge, and granulated lead. When the fire has been raiſed, and the additions well incorporated with the matt, let ſome caſt or filed iron be thrown into the liquid maſs, which being more diſpoſed than lead is to unite with ſulphur, will ſeparate and precipitate the latter metal, and along with it the ſilver or gold contained in the matt. This method was introduced by Scheffer, and is practiſed at Adelfors in Smoland. In this work the proportion of the ſeveral materials is, four quintals of matt, two quintals of black copper containing ſome lead with the perfect metal, one quintal of galena, one quintal of litharge, a fifth part of a quintal of granulated lead, and an equal quantity of caſt iron.

The ſilver in this, and in all other inſtances where it is united with lead, is to be afterwards ſeparated from the lead by cupellation; which proceſs is deſcribed at the articles Essay *of the* Value *of* Silver, *and* Refining.

are chiefly employed for crude fusions; and particularly for the slate copper-ore. These furnaces are above eighteen feet high. A too great height is attended with an inconvenience, besides the trouble of supplying it with ore and fuel, which is, that the charcoal is mostly consumed before it gets down where the greatest heat is required, and is then rendered incapable of maintaining a fire sufficiently intense.

All the furnaces which we have mentioned are supplied with large bellows, moved by the arbor of a wheel, which is turned round by a current of water.

The only kind of furnace for smelting ores where bellows are not employed, is what is called a *reverberatory furnace*. The Germans call it a *wind-furnace*. It is also distinguished by the name of *English furnace*, because the invention of it is attributed to an English physician of the name of *Wright*, who was well versed in chemistry; and because the use of it was first introduced in England about the end of the last century, where it is much employed, as well as in several other countries, as at Konigsberg, in Norway. *See* PLATE II. *Fig.* 14 *and* 15.

The length of these furnaces is about eighteen feet, comprehending the masonry: their breadth is twelve feet, and their height nine feet and a half. The hearth is raised three feet above the level of the foundery: on one side is the fire-place, under which is an ash-hole hollowed in the earth; on the other side is a bason made, which is kept covered with fire when there is occasion: on the anterior side of this furnace there is a chimney, which receives the flame after it has passed over the mineral that is laid upon the hearth. This hearth, which is in the interior part of the furnace, is made of a clay capable of sustaining the fire. The advantage of this furnace is, that bellows are not necessary, and consequently it may be constructed where there is no current of water, and wherever the mine happens to be. This furnace has a hole in its front through which the scoria is drawn out; and a bason, as we have said, on one side, made with sand, in which are oblong traces for the reception of the *matt*, and of the *black copper*, when they flow out of the furnace.

Copper is generally mineralised, not only by sulphur and arsenic, but also by semimetals and pyritous matters, and is frequently mixed with other metals. As this metal has great affinity with sulphur and arsenic, it is almost impossible to disengage it from them entirely by roasting: hence in the smelting in great, nothing is obtained by the first operation but a copper-matt, which contains all the principles of the ore, excepting the earthy and stony parts, particularly when the ore is smelted, crude, and unroasted. Afterwards this matt must be again roasted and fused. The produce of this second fusion begins still more to resemble copper, but is not malleable. It continues mixed with almost all the minerals, particularly with the metals. As it is frequently of a black color, it is always called *black copper*, when it is unmalleable, whatever its color happens really to be.

As, of all the imperfect metals, copper is most difficultly burnt and scorified, it is again remelted several times, in order to burn and scorify the metallic substances mixed with it; and this is done till the copper is perfectly pure, which is then called *red*, or *refined copper*, and these last fusions are called the fining and refining of it: Red copper contains no metals but gold and silver, if any of these happened to be in the ore.

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In order to avoid all these fusions, it has been proposed to treat in the humid way certain copper ores, particularly those which are very pyritous. This method consists in making blue vitriol from the ore, by roasting and lixiviating it, and in precipitating pure copper from this lixivium, which is called *cement-water*, by means of iron: but it is not much practised, because it has been observed, that all the copper contained in the ore was not procured by this means.

As expence is not much regarded in small essays and experiments, these fusions are much abridged and facilitated by adding at first saline and glassy fluxes; and then by refining the black copper with lead in the cupel, as gold and silver are done. In this method of refining it is to be most carefully observed, that the metal be fused as quickly as possible, and exposed to no more heat than is necessary, lest it be calcined.

When the black copper contains some iron, but not a great deal, the lead presently separates the iron from it, and makes it rise to the surface of the copper: but if the iron be in too large a proportion, it prevents the lead from uniting with the copper. These two phenomena depend on the same cause, which is, that lead and iron cannot unite.

Frequently copper ores contain also a quantity of silver sufficient to make its extraction by particular processes profitable. It was long before any process could be thought of for this purpose which was not too expensive and troublesome: but at length it is accomplished by the excellent operation, called *eliquation*. *See the word* ELIQUATION.

The copper from which silver has been separated by eliquation must be refined after this operation, as it is generally black copper from which silver is extracted: but even if it had not been black copper which was employed for this operation, it would require to be refined on account of a little lead it always retains. It is therefore carried to the refiners furnace, where this operation is performed by help of bellows, the blast of which is thrown upon the surface of the melted metal. As in this refining of copper the precise time when it becomes pure cannot be known, because scoria is always formed on its surface, it is necessary to use an *essay-iron*, the polished end of which being dipt in melted copper, shews that this metal is pure when the copper adhering to the iron falls off as soon as it is dipt in cold water.

When this mark of the purity of the copper has been observed, its surface ought to be well cleaned; and as soon as it begins to fix, it must be sprinkled with a broom or besom dipt in cold water. The surface of the copper which is then fixing, being suddenly cooled by the water, detaches itself from the rest of the metal, is taken hold off by tongs, and is thrown red-hot into cold water. By again sprinkling water on the mass of copper, it is all of it reduced into plates, which are called *rosettes*, and these plates are what is called *rosette-copper*. *(p)*

(p) The copper of pyritous cupreous ores cannot be obtained without several operations, which vary according to the nature of the ores. These operations are chiefly roastings and fusions. By the first fusion a matt is produced, which is afterwards to be roasted; and thus the fusions and roastings are to be alternately applied, till by the last fusion copper is obtained. These methods of treating pyritous copper ores depend on the two following facts: 1. Sulphur is more disposed to unite with iron than with copper.

We shall not enter into further details concerning the operations made in great upon the different minerals, that we may not exceed the bounds intended

2. The iron of these ores is destructible by the burning sulphur during the roasting or the fusion of the ores, while the copper is not injured. This fact appears from experiments mentioned by Scheffer and by Wallerius, and from the daily practice of smelting cupreous ores.

From these facts we learn, 1. That sulphur may be employed to separate and destroy iron mixed with copper; 2dly, that iron may be employed to separate the sulphur from copper, as is sometimes done in the essay of sulphurated copper-ores; and, 3dly, that by adjusting the proportion of the iron and sulphur to each other in the smelting of copper-ores, these two substances may be made to destroy each other, and to procure a separation of the copper; and this adjustment may be effected, by adding sulphur or sulphureous pyrites to the copper-ore, when the quantity of sulphur contained in this ore relatively to the iron is too small; or by adding iron when the sulphur predominates; or by roasting, by which the superfluous sulphur may be expelled, and no more left than is sufficient for the destruction of the iron contained in the ore. We shall apply these principles to the following cases.

1. When the quantity of sulphur and of iron in a copper-ore is small, and especially when the iron does not too much abound, a previous roasting will at once calcine the iron, and expell most of the sulphur; so that by one fusion the calcined iron may be scorified, and black copper may be obtained. If the sulphur has not been sufficiently expelled, a second roasting and fusion are requisite; for the whole quantity of sulphur ought not to be expelled during the first roasting; but as much ought to be left as is sufficient for the scorification of the calcined iron, otherwise this might, during the fusion, be again revived and united with the copper.

2. If, in a copper-ore, the quantity of iron be too great, relatively to the sulphur, some sulphurated pyrites, especially that kind which contains copper, ought to be added, that a matt may be obtained, and that the iron may be calcined and scorified.

3. When the quantity of sulphur and iron is very great, that is, when the ore is very pyritous and poor, it ought to be first formed into a matt; by which it is separated from the adherent earths and stones, and the bulk is diminished: then by repeated and alternate roastings and fusions, the copper may be obtained.

4. When the quantity of sulphur in an ore is greater than is sufficient for the forming a matt, the superfluous quantity ought to be previously expelled by roasting.

The copper thus at first obtained is never pure, but is generally mixed with sulphur or with iron. It is called *black copper*. This may be refined in furnaces, or on hearths.

In the former method, to the copper when melted a small quantity of lead is added, which unites with the sulphur, and is scorified together with the iron, and floats upon the surface of the melted copper. This purification of copper by means of lead is similar to the refining of silver by cupellation, and is founded on the property of lead, by which it is more disposed to unite with sulphur than copper is, and on a property of copper, by which it is less liable than any other imperfect metal to be scorified by lead. But as copper is also capable of being scorified by lead, this operation must be no longer continued, and no more lead must be employed than is sufficient for the separation of the sulphur, and for the scorification of the iron.

The copper might also be purified from any remaining sulphur by adding a sufficient quantity of iron to engage the sulphur. Thus Mr. Scheffer found, that by adding to sulphurated copper from $\frac{1}{20}$th to $\frac{1}{30}$th of old cast iron, he rendered the copper pure and ductile. *See his Dissertation on the Parting of Metals amongst the Swedish Memoirs for the year* 1752. In this purification, the quantity of iron added ought not to be too little, else all the sulphur will not be separated; and it ought not to be too great, else the superfluous quantity will unite with and injure the purity of the copper. The fusion and scorification, with addition of lead, seems to be the best method for the last purification of copper.

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for this work. Besides, what remains to be said upon the ores of mercury, antimony, bismuth, arsenic, and cobalt, is already sufficiently explained in the different articles of this Dictionary relating to these substances, and to their products. The fusion in great of ores of iron would indeed particularly deserve to be treated more extensively, on account of its importance; but we observe, that the general principles of the smelting of ores contained in the present article are as applicable to ores of iron as of other metals, and for the particular details we are obliged to refer to good Treatises, which are not wanting on this subject, and particularly to the *Art of Forges and Iron-furnaces*, described most exactly by the Marquis de Courtivron, of the Royal Academy of Sciences, and by M. Bouchu, a correspondent of that Academy; a work which makes part of a general description of the Arts undertaken by that illustrious company. (*q*)

(*q*) In this work, which pretends to treat of the principles of arts in general, we ought certainly not to omit some description of the methods of procuring and manufacturing a metal, so extensively useful, that without it no other art could have been perfected, and even, as some writers have observed, mankind could not have been civilized.

In the article IRON, the author of the Dictionary has described the chemical properties of that metal, or its effects when acted upon by fire, acids, and other substances. The subjects of this note and of the article STEEL are the processes by which iron is obtained from its ores, and reduced to the several states of *cast iron*, *forged iron*, and *steel*, and the properties of this metal in these several states, which render it fit for the various uses to which it is daily applied.

Notwithstanding the great importance of these subjects, and the labors of Reaumur, Swedenborgius, and of some other authors, we have still a very imperfect knowledge of the causes of the differences of the several kinds of ores, of the methods of smelting best adapted to these differences, of the causes of the good and bad qualities of different kinds of iron, and of the means of so meliorating this metal, that we may obtain tough and ductile iron from any of its ores.

Swedenborgius has very industriously and exactly described the different processes now used in most parts of Europe for the smelting of ores of iron, for the forging of that metal, and for the conversion of it into steel: but we do not find that he or any other author have, by experiments and discoveries, contributed much to the illustration or to the improvement of this part of metallurgy, unless, perhaps, we except those of Mr. Reaumur, concerning the softening of cast iron by cementation with earthy substances.

The *ores of iron* are known to vary much in their appearance, in their contents, in their degrees of fusibility, in the methods necessary for the extraction of their contained metal, and in the qualities of the metal when extracted.

Most ores require to be *roasted* previously to their fusion; some more slightly, and others with a more violent and longer-continued fire. Those which contain much sulphur, arsenic, or vitriolic acid, require a long-continued and repeated roasting, that the volatile matters may be expelled.

Some ores require a very slight roasting only, that they may be dried and rendered friable. Such are the ores called *bog ores*, and others, which being in a calcined state, and containing no sulphureous or inflammable matter, would, by a further calcination, be rendered less capable of uniting with phlogiston, and consequently of being reduced to a metallic state.

Also the ores which are attractable by magnets, and which contain iron in a state nearly metallised, require little or no roasting.

The roasting of ores of iron is performed by kindling piles, consisting of strata of fuel and of ore placed alternately upon one another, (*See* PLATE II. *Fig.* 11. *and* 12.) or in furnaces similar to those commonly employed for the calcination of lime-stone.

Some authors advise the addition of some calcareous earth to sulphureous ores during the roasting, that the sulphur may be absorbed

DCXXXII. SNOW *of* ANTIMONY. The flowers of regulus of antimony are so called. *See* FLOWERS *of* REGULUS *of* ANTIMONY.

sorbed by this earth when converted into quicklime. But we may observe, that the quicklime cannot absorb the sulphur or sulphureous acid, till these be first extricated from the ore, and does therefore only prevent the dissipation of these volatile matters; and, secondly, that the sulphur thus united with the quicklime forms a hepar of sulphur, which will unite with and dissolve the ore during its fusion, and prevent the precipitation of the metal.

The next operation is the *fusion* or *smelting* of the ore. This is generally performed in furnaces or towers, from twenty to thirty feet high, in the bottom of which is a bason for the reception of the fluid metal. *See a Section and Description of this Furnace in* PLATE II. *Fig.* 20, *and the Explanation of that Figure.* When the furnace is sufficiently heated, which must be done at first very gradually, to prevent the cracking of the walls; a quantity of the ore is to be thrown in, from time to time, at the top of the furnace, along with a certain quantity of fuel and of limestone, or whatever other flux is employed. While the fuel below is consumed by the fire excited by the wind of the bellows, the ore, together with its proportionable quantity of fuel and of flux, sink gradually down, till they are exposed to the greatest heat in the furnace. There the ore and the flux are fused, the metallic particles are revived by the phlogiston of the fuel, are precipitated by means of their weight through the scoria formed of the lighter earthy parts of the flux and of the ore, and unite in the bason at the bottom of the furnace, forming a mass of fluid metal covered by a glassy scoria. When a sufficient quantity of this fluid metal is collected, which is generally twice or thrice in twenty-four hours, an aperture is made, through which the metal flows into a channel or groove made in a bed of sand; and from thence into smaller lateral or connected channels, or other moulds. There it is cooled, becomes solid, and retains the forms of the channels or moulds into which it flows. The piece of iron formed in the large channel is called *a sow*, and those formed in the smaller channels are called *pigs*. Sometimes the fluid iron is taken out of the furnace by means of ladles, and poured into moulds, ready prepared, of sand or of clay, and is thus formed into the various utensils and instruments for which cast iron is a proper material.

The *scoria* must be, from time to time, allowed to flow out, when a considerable quantity of it is formed, through an aperture made in the front of the furnace for that purpose. A sufficient quantity of it must, however, be always left to cover the surface of the melted iron, else the ore which would fall upon it, before the separation of its metallic from its unmetallic parts, would lessen the fluidity and injure the purity of the melted metal. This scoria ought to have a certain degree of fluidity; for if it be too thick, the revived metallic particles will not be able to overcome its tenacity, and collect together into drops, nor be precipitated. Accordingly, a scoria, not sufficiently fluid, is always found to contain much metal. If the scoria be too thin, the metallic particles of the ore will be precipitated before they are sufficiently metallized, and separated from the earthy and unmetallic parts. A due degree of fluidity is given to the scoria by applying a proper heat, and by adding fluxes suited to the ore.

Some ores are fusible without addition, and others cannot be smelted without the addition of substances capable of facilitating their fusion.

The *fusible ores* are those which contain sulphur, arsenic, or are mixed with some fusible earth.

The *ores difficultly fusible* are those which contain no mixture of other substance. Such are most of the ores which are attractable by magnets, and which contain iron in a state nearly metallic. As iron itself, when purified from all heterogeneous matters, is scarcely fusible without addition, so the metal contained in these purer kinds of ores cannot be easily extracted without the addition of some fusible substance. 2. Those which are mixed with some very refractory substance. Some of these refractory ores contain arsenic; but as this substance facilitates the fusion of iron, we may presume

that

DCXXXIII. S O A P. The name *soap* was formerly employed only to signify combinations of alkaline salts with oils, that is, compounds in which

that their refractory quality depends upon a mixture of some unmetallic earth or other unfusible substance.

Perhaps the fusibility of different ores depends greatly on the degree of calcination to which the metal contained in them has been reduced; since we have reason to believe that, by a very perfect calcination, some metals, at least, may be reduced to the state of an earth almost unfusible, and incapable of that intimate union with phlogiston in which metallisation consists (*see the article* METALS); and since we know, that in every calcination and subsequent reduction of a given quantity of any imperfect metal, a sensible part of that quantity is always lost or destroyed, however carefully these operations may have been performed. If this notion be just, the most probable means of improvement in the smelting of ores of imperfect metals, especially of iron, seem to be by discovering some method of effecting the combination or intimate union of phlogiston with metallic earths or calxes, more compleatly and certainly than by immediately exposing them to a melting heat, in which those metallic particles only can be revived, that are already much disposed to metallisation. That some of these ores are already too much calcined, appears from the instance above-mentioned of the *bog ores*, which are injured by roasting; and even the great height of the common smelting furnaces, although advantageous to many ores that require much roasting, is said to be injurious to those which are already too much calcined, by exposing them to a further calcination, during their very gradual descent, before they arrive at the hottest part of the furnace, where they are fused.

Further, when we consider how many instances occur of combinations which can be effected only by slow degrees, we have reason to hope, that methods of more effectually combining phlogiston with metallic earths may be discovered, by which a larger proportion of metal may be obtained from the ores, especially the calciform ores of iron, and perhaps of other imperfect metals, than is now obtained by the methods commonly practised.

Various *substances are added to assist the fusion of ores* difficultly fusible. These are; 1. *Ores* of a fusible quality, or which, being mixed with others of a different quality, become fusible: accordingly, in the great works for smelting ores of iron, two or more different kinds of ore are commonly mixed, to facilitate the fusion, and also to meliorate the quality of the iron. Thus an ore yielding an iron which is brittle when hot, which quality is called *red-short*, and another ore which produces iron brittle when cold, or *cold-short*, are often mixed together; not, as is sometimes supposed, that these qualities are mutually destructive of each other, but that each of them is diminished in the mixed mass of iron, as much as this mass is larger than the part of the mass originally possessed of that quality. Thus, if from two such ores the mass of iron obtained consists of equal parts of cold-short and of red-short iron, it will have both these qualities, but will be only half as *cold-short* as iron obtained solely from one of the ores, and half as *red-short* as iron obtained only from the other ore. 2. *Earths* and *stones* are also generally added to facilitate the fusion of iron ores. These are such as are fusible, or become fusible when mixed with the ore, or with the earth adhering to it. Authors direct that, if this earth be of an argillaceous nature, limestone or some calcareous earth should be added; and that if the adherent earth be calcareous, an argillaceous earth should be added; because these two earths, though singly unfusible, yet, when mixed, mutually promote the fusion of each other: but as limestone is almost always added in the smelting of iron-ores, and as in some of these, at least, no argillaceous earth appears to be contained, I am inclined to believe, that it generally facilitates the fusion, not by uniting with an argillaceous earth, but by uniting with that part of the ore which is most perfectly calcined, and least disposed to metallisation; since we know, that by mixing a calciform or roasted ore of iron with calcareous earth, without any inflammable matter, these two substances may be totally vitrified. *See Experiments made upon Quicklime, and upon Iron,* by

oils are rendered miscible with water, by means of an alkali. But since chemists, by a more exact examination of the nature of bodies, have dis-

by Mr. Brandt, in the Swedish Memoirs for the years 1749 *and* 1751.

Some authors pretend, that a principal use of the addition of lime-stone in the smelting of iron-ores is to absorb the sulphur, or vitriolic acid, of these ores: but, as we have already observed, a hepar of sulphur is formed by that mixture of calcareous earth and sulphur, which is capable of dissolving iron in a metallic state; and thus the quantity of metal obtained from an ore not sufficiently divested of its sulphur, or vitriolic acid, (which, by uniting with the phlogiston of the fuel, is formed into a sulphur during the smelting) must be considerably diminished, though rendered purer, by addition of calcareous earth: hence the utility appears of previously expelling the sulphur and vitriolic acid from the ore by a sufficient roasting. 3. The *scoria* of former smeltings is frequently added to assist the fusion of the ore; and, when the scoria contains much iron, as sometimes happens in ill conducted operations, it also encreases the quantity of metal obtained.

The quantity of these fusible matters to be added varies according to the nature of the ore; but ought in general to be such, that the scoria shall have its requisite degree of thinness, as is mentioned above.

The *fuel* used in most parts of Europe for the smelting of ores of iron is charcoal. Lately, in several works in England and Scotland, iron-ore has been smelted by means of pitcoal, previously reduced to cinders or *coaks*, by a kind of calcination similar to the operation for converting wood into charcoal, by which the aqueous and sulphureous parts of the coal are expelled, while only the more fixed bituminous parts are left behind. In France, pitcoal not calcined has been tried for this purpose, but unsuccessfully. The use of *peat* has also been introduced in some parts of England.

The quality of the iron depends considerably upon the quality and also upon the quantity of the fuel employed. Charcoal is fitter than coaks for producing an iron capable of being rendered malleable by forging.

The quantity of fuel, or the intensity of the heat, must be suited to the greater or less fusibility of the ore. Sulphureous, and other ores easily fusible, require less fuel than ores difficultly fusible. In general, if the *quantity of fuel be too small*, and the heat not sufficiently intense, all the iron will not be reduced, and much of it will remain in the scoria, which will not be sufficiently thin. This defect of fuel may be known by the blackness and compactness of the scoria, by the qualities of the iron obtained, which in this case is hard, white, light, intermixed with scoria, smooth in its texture, without scales or grains, rough and convex in its surface, and liable to great loss of weight by being forged; and, lastly, it may be known by observing the color and appearance of the drops of metal falling down from the smelted ore, and of the scoria upon the surface of the fluid metal, both which are darker-colored than when more fuel is used. When the *quantity of fuel is sufficiently large*, and the heat is intense enough, the iron is darker-colored, denser, more tenacious, contains less scoria, and is therefore less fusible, and loses less of its weight by being forged. Its surface is also smoother and somewhat concave; and its texture is generally granulated. The scoria, in this case, is of a lighter color and less dense. The drops falling from the smelted ore and the liquid scoria in the furnace appear hotter and of a brighter color. When the quantity of fuel is too great, and the heat too intense, the iron will appear to have a still darker color, and more conspicuous grains or plates, and the scoria will be lighter, whiter, and more spungy. The drops falling from the smelted ore, and the fluid scoria, will appear to a person looking into the furnace through the blast-hole to be very white and shining hot. The quantity of charcoal necessary to produce five hundred weight of iron, when the ore is rich, the furnace well contrived, and the operation skilfully conducted, is computed to be about forty cubic feet; but is much more in contrary circumstances.

The *time, during which the fluid metal ought to be kept in fusion* before it is allowed to flow out of the

covered, that acids, and even other saline substances, may also be united with oils, and may render these miscible with water, they have generalised the name

the furnace must be also attended to. How long that time is, and whether it ought not to vary according to the qualities of ores and other circumstances, we cannot determine. In some works the metal is allowed to flow out of the furnace every six or eight, and in others only every ten or twelve hours. Some workmen imagine, that a considerable time is necessary for the concoction of the metal. This we are certain of, that the iron undergoes some change by being kept in a fluid state; and that if its fusion be prolonged much beyond the usual time, it is rendered less fluid, and also its cohesion, when it becomes cold, is thereby greatly diminished. The Marquis de Courtivron says, that the cohesion may be restored to iron in this state, by adding to it some vitrescible earth, which he considers as one of the constituent parts of iron, and which he thinks is destroyed by the fusion too long continued. That the fusibility of cast iron does depend on an admixture of some vitrescible earth, appears probable from the great quantity of scoria forced out of iron during its conversion into malleable or forged iron, and from the loss of fusibility which it suffers nearly in proportion to its loss of scoria. The quantity of iron daily obtained from such a furnace as we have described, is from two to five tons in twenty-four hours, according to the richness and fusibility of the ore, to the construction of the furnace, to the adjustment of the due quantity of flux and of fuel, and to the skill employed in conducting the operation.

The *quality of the iron* is judged by observing the appearances during its flowing from the furnace, and when it is fixed and cold. If the fluid iron, while it flows, emits many and large sparkles; if many brown spots appear on it while it is yet red-hot; if when it is fixed and cold, its corners and edges are thick and rough, and its surface is spotted; it is known to have a red-short quality. If, in flowing, the iron seems covered with a thin glassy crust, and if, when cold, its texture be whitish, it is believed to be cold-short. Mr. Reaumur says, that dark-colored cast iron is more impure than that which is white. The Marquis de Courtivron is of a contrary opinion. But no certain rules for judging of the quality of iron before it be forged can be given. From brittle cast iron, sometimes ductile forged iron is produced. Cast iron with brilliant plates and points, when forged, becomes sometimes red-short and sometimes cold-short. Large shining plates, large cavities called *eyes*, want of sufficient density, are almost certain marks of bad iron; but whether it will be cold or red-short cannot be affirmed till it be forged. Whiteness of color, brittleness, closeness of texture, and hardness, are given to almost any cast iron by sudden cooling; and we may observe, that in general the whiter the metal is, the harder it is also, whether these properties proceed from the quality of the iron, or from sudden cooling; and that, therefore, the darker-colored iron is fitter for being cast into moulds, because it is capable in some measure of being filed and polished, especially after it has been exposed during several hours to a red-heat in a reverberatory furnace, and very gradually cooled. This operation, called by workmen *annealing*, changes the texture of the metal, renders it softer, and more capable of being filed than before, and also considerably less brittle.

Mr. Reaumur found, that by cementing cast iron with absorbent earths in a red-heat, the metal may be rendered softer, tougher, and consequently a fit material for many utensils formerly made of forged iron. Whether cementation with absorbent earths gives to cast iron a greater degree of these properties than the annealing commonly practised, has not been yet determined.

In Navarre, and in some of the southern parts of France, iron-ore is smelted in furnaces much smaller, and of a very different construction from those above described. A furnace of this kind consists of a wide-mouthed copper-caldron, the inner surface of which is lined with masonry a foot thick. The mouth of the caldron is nearly of an oval or elliptic form. The space or cavity contained by the masonry is the furnace in which the ore is smelted. The depth of this cavity is equal to two feet and a half: the larger diameter of the oval mouth of the

name of ſoap, and the beſt chemiſts give it now to all combinations of any ſaline ſubſtances with oils, rendered miſcible with water by means of theſe ſaline

cavity is about eight feet, and its ſmaller diameter is about ſix feet: the ſpace of the furnace is gradually contracted towards the bottom, the greateſt diameter of which does not exceed ſix feet: eighteen inches above the bottom is a cylindrical channel in one of of the longer ſides of the caldron and maſonry, through which the nozzle of the bellows paſſes. This channel, and alſo the bellows-pipe, are ſo inclined, that the wind is directed towards the loweſt point of the oppoſite ſide of the furnace. Another cylindrical channel is in one of the ſhorter ſides of the furnace, at the height of a few inches from the bottom, which is generally kept cloſed, and is opened occaſionally to give paſſage to the ſcoria; and above this is a third channel in the ſame ſide of the furnace, through which an iron inſtrument is occaſionally introduced to ſtir the fluid metal, and to aſſiſt, as is ſaid, the ſeparation of the ſcoria from it. The greateſt height of this channel is at its external aperture on the outſide of the furnace, and its ſmaller height is at its internal aperture; ſo that the inſtrument may be directed towards the bottom of the furnace; but the ſecond channel below it has a contrary inclination, that when an opening is made, the ſcoria may flow out of the furnace into a baſon placed for its reception. When the furnace is heated ſufficiently, the workmen begin to throw into it alternate charges of charcoal, and of ore previouſly roaſted. They take care to throw the charcoal chiefly on that ſide at which the wind enters, and the ore at the oppoſite ſide. At the end of about four hours a maſs of iron is collected at the bottom of the furnace, which is generally about ſix hundred weight: the bellows are then ſtopt; and when the maſs of iron is become ſolid, the workmen raiſe it from the bottom of the furnace, and place it, while yet ſoft, under a large hammer, where it is forged. The iron produced in theſe furnaces is of the beſt quality; the quantity is alſo very conſiderable, in proportion to the quantity of ore, and to the quantity of fuel employed. In theſe furnaces no limeſtone or other ſubſtance is uſed to facilitate the fuſion of the ore. We ſhould receive much inſtruction concerning the ſmelting of iron-ore, if we knew upon what part of the proceſs or circumſtance, the excellence of the iron obtained in theſe furnaces depends; whether on the quality of the ore; on the diſuſe of any kind of flux, by which the proportion of vitreous or earthy matter, intermixed with the metallic particles, is diminiſhed; on the forging while the iron is yet ſoft and hot, as the Marquis de Courtivron thinks; or on ſome other cauſe, not obſerved.

The iron thus produced by ſmelting ores is very far from being a pure metal; and though its fuſibility renders it very uſeful for the formation of cannon, pots, and a great variety of utenſils, yet it wants the ſtrength, toughneſs, and malleability, which it is capable of receiving by further operations.

Caſt-iron ſeems to contain a large quantity of vitreous or earthy matter mixed with the pure iron; which matter is probably the chief cauſe of its fuſibility, brittleneſs, hardneſs, and other properties by which it differs from forged iron. The ſulphur, arſenic, and other impurities of the ores, which are ſometimes contained in caſt iron, are probably only accidental, and may be the cauſes of the red-ſhort quality, and of other properties of certain kinds of iron: but the earthy matter above-mentioned ſeems principally to diſtinguiſh caſt iron from forged or malleable iron; for, firſt, by depriving the former of this earthy matter, it is rendered malleable, as in the common proceſs hereafter to be deſcribed; and, ſecondly, by fuſing malleable iron with earthy and vitreſcible matters, it loſes its malleability, and is reſtored to the ſtate and properties of caſt iron.

The earthy vitreous matter contained in caſt iron conſiſts probably of ſome of the ferruginous earth or calx of the ore not ſufficiently metalliſed, and alſo of ſome unmetallic earth. Perhaps it is only a part of the ſcoria which adheres to, and is precipitated with, the metallic particles, from which it is more and more ſeparated, as the heat applied is more intenſe, and as the fuſion is longer continued.

To ſeparate theſe impurities from caſt iron, and to unite the metallic parts more cloſely

ſubſtances. The vegetable kingdom contains many ſuch ſaline, oily combinations ſoluble in water. All vegetable acids, fluor or concrete; eſſential ſalts; ſac-

cloſely and compactly, and thus to give it the ductility and tenacity which render this metal more uſeful than any other, are the effects produced by the following operations.

The firſt of theſe operations is a fuſion of the iron, by which much of its impurities is ſeparated in form of ſcoria; and by the ſecond operation, a further and more compleat ſeparation of theſe impurities, and alſo a cloſer compaction of the metallic particles, are effected by the application of mechanical force or preſſure, by means of large hammers.

Some differences in the conſtruction of the forge or furnace, in which the *fuſion* or *refining of caſt iron* is performed, in the method of conducting the operation, and in ſome other circumſtances, are obſerved to occur in different places. We ſhall deſcribe, from Suedenborgius, the *German method*.

The fuſion of the caſt-iron, which is to be rendered malleable, is performed upon the hearth of a forge ſimilar to that uſed by blackſmiths: at one ſide of this hearth is formed a cavity or fire-place, which is intended to contain the fuel and the iron to be melted: this fireplace is twenty inches long, eighteen inches broad, and twelve or fourteen inches deep: it is bounded on three ſides by three plates of caſt-iron placed upright; and on the fourth ſide, which is the front, or that part neareſt to which the workmen ſtand, by a large forge-hammer, through the eye of which the ſcoria is at certain times allowed to flow. The floor alſo of the fire-place is another caſt-iron plate. The thickneſs of theſe plates is from two to four inches. One of the upright ſide-plates reſts againſt a wall, in an aperture thro' which a copper tube, called the *tuyere*, is luted with clay. This tube is a kind of caſe or covering for the pipe of a pair of bellows placed behind the wall, and its direction is therefore parallel to that of the bellows-pipe; but it advances about half a foot further than this pipe into the fire-place; and thus gives greater force to the air, which it keeps concentrated, or prevents the divergency of the air, till it is required to act. The tube reſts upon the upper edge of the ſide-plate which leans againſt the wall, nearer to the back-part than to the front of the fire-place, and in ſuch an oblique direction, that the wind ſhall be impelled towards the furtheſt part of the floor of the fire-place, or where this floor is interſected by the oppoſite ſide-plate. The obliquity of the tuyere ought to vary according to the quality of the iron: and therefore, in every operation, it may be ſhifted till its proper poſition is found. The more nearly its direction approaches to a horizontal plane, the more intenſe is the heat; but a larger quantity of fuel is conſumed than is even proportional to the encreaſe of heat, becauſe the flame is not then ſo well confined. When the iron is eaſily fuſible, great heat is not required: the tuyere may then decline conſiderably from the horizontal plane, and thus fuel may be ſaved. This tuyere, though made of copper, a metal more eaſily fuſible than iron, is preſerved from fuſion by the conſtant paſſage of cold air through it. It muſt be carefully kept open, and cleanſed from the ſcoria, which would be apt to block its cavity, by which not only the heat would be too much diminiſhed for the ſucceſs of the operation, but the tube itſelf would be melted.

To prepare for the fuſion, a quantity of ſcoria of a former operation is thrown into the fire-place, till one-third part of this be full; and the remaining two thirds of the fire-place are to be filled with ſmaller ſcoria, coal-duſt, and ſparks ejected from hot iron. Theſe matters, being fuſible, form a bath for the reception of the iron when melted. Upon this bed of ſcoria, the maſs of caſt-iron to be melted is placed; ſo that one end of it ſhall be within the fire-place, oppoſite to the tuyere, and at the diſtance of about four or five inches from its aperture; and the other end ſhall ſtand without the fire-place, to be puſhed in, as the former is melted. The upper ſide of the maſs of iron ought to be in the ſame horizontal plane as the upper part of the orifice of the tuyere, that the wind may, by means of the obliquity of its courſe, ſtrike upon and paſs along the underſide of the maſs; but if the iron be difficultly fuſible, the tuyere is to be diſpoſed more horizontally, ſo that the wind ſhall ſtrike directly upon the maſs of iron; and that one part of the blaſt ſhall graze along the upper ſurface, and the other part along the under ſurface of the iron.

charine juices; the extractive matter of plants, properly so called, are saponaceous substances, or acid soaps. In many of these soaps, such as essential

iron. The mass of iron weighs generally from two hnndred to four hundred pounds. Sometimes two or three smaller masses are put one above another, so as not to touch. When these are of different qualities, the cold-short piece is placed undermost, that being more unfusible than the red-short. The iron being placed, charcoal-powder is thrown on both sides, and coals are accumulated above, so as to cover entirely the iron.

The coals are then to be kindled, and the bellows are made to blow, at first slowly, and afterwards with more and more force. The iron is gradually liquefied, and flows down in drops through the melted scoria to the bottom of the fire-place; during which the workmen frequently turn the iron, so that the end opposed to the blast of wind may be equally exposed to heat, and uniformly fused. While the coals are consumed, more are thrown on, so that the whole may be kept quite covered. During the operation, a workman frequently sounds the bottom and corners of the fire place, by means of a bar or poker, raises up any mass of metal which he finds adhering to these, and exposes them to the greatest heat, that they may be more perfectly fused.

When all the iron is fused, no more coals are to be added; but the melted mass is to remain half uncovered for some time; during which the iron boils and bubbles, and its surface swells and rises higher and higher. When the iron has risen as high as the upper edge of the fire place, the coals upon its surface must be removed; and by thus exposing it to cold air, its ebullition and swelling subside. In this state, or coction, the iron is kept during half an hour or more, by adding occasionally pieces of good coal, which maintain a sufficient heat, without covering entirely the surface of the mass. During this coction, the workmen allow the orifice of the tuyere to be half stopped up by the scoria, that the air may not blow upon the iron with all its force, by which it would be too much cooled. Accordingly, when they think that the coction has continued sufficiently long, they clear the passage of the tuyere, and the mass is soon cooled by the cold air. At the same time also, they open a passage in the eye of the hammer placed in the front of the fire-place, through which some of the scoria is allowed to flow out. When the iron has become solid, the bellows are stopt, the coals are removed, and the mass is left during an hour; and then the workmen raise it from the fire-place, turn it upside down, and proceed to the second coction or fusion of the iron.

For this second operation, the mass is to be so placed, that one part of it shall rest upon the tuyere, and the other upon the scoria remaining in the fire-place. This scoria is to be disposed in an oblique direction parallel to the tuyere, by which means the wind of the bellows is obliged to pass all along the under side of the mass of iron. About the sides of the mass, charcoal powder and burnt ashes are thrown; but towards the tuyere, dry and entire pieces of coals are placed, to maintain the fire. When these are kindled, more coals are added, and the fire is gradually excited. The workman attends to the direction of the flame, that it pass equally along the under surface of the iron, quite to the further extremity, and that it do not escape at the sides, nor be reverberated back towards the tuyere, by which this copper tube might be melted. During this fusion, pieces of iron are apt to be separated from the mass, and to fall down unfused to the bottom and corners of the fire-place. These are carefully to be searched for, and exposed to the greatest heat till they are melted. When the whole mass is thus brought into perfect fusion, the coals are removed, and the wind blowing on its surface, whirls and dissipates the small remaining pieces of scoria, and sparks thrown out from the fluid iron. This jet of fire continues about seven or eight minutes, and the whole operation about two hours. In this second fusion the scoria is to be thrice removed, by opening a passage through the eye of the hammer. The first time of removing the scoria is about twenty minutes from the kindling of the fire; the second time is about forty minutes after the first; and the third time is near the end of the operation.

The mass is then removed from the hearth, and

falts and vegetable acids, the faline part predominates over the oily part, and they have therefore been confidered rather as falts, than as foaps. But the oil

and put upon the ground of the forge, where it is cleanfed from fcoria, and beat into a more uniform fhape. It is then placed on an anvil, where, by being forged, it receives a form nearly cubical. This mafs is to be divided into five, fix, or more pieces, by means of a wedge; and thefe are to be heated and forged till they are reduced to the form of the bars, commonly fold.

In fome forges, the iron is fufed only once, and in others it fuffers three fufions, by which it is faid to be rendered very pure. Where only one fufion is practifed, it is called the *French method*. In this, no greater quantity of iron is fufed at once than is fufficient to make one bar. The fireplace is of confiderably lefs dimenfions, and efpecially is lefs deep than in the German method above defcribed. The fire is alfo more intenfe, and the proportion of fuel confumed to the iron is greater. The iron, when melted, is not kept in a ftate of ebullition as is above defcribed; but this ebullition is prevented by ftirring the fluid mafs with an iron bar, till it is coagulated, and becomes folid.

By thefe operations, fufion and forging, the iron lofes about $\frac{1}{11}$ parts of its former weight, fometimes more and fometimes lefs, according to the quality of the caft iron employed; it is purified from the vitreous and earthy parts which were intermixed with it, its metallic particles are more clofely compacted, its texture is changed, and it is rendered more denfe, foft, malleable, tough, and difficultly fufible.

The degrees however of thefe qualities vary much in different kinds of iron. Thus fome iron is tough and malleable, both when it is hot and when it is cold. This is the beft and moft ufeful iron. It may be known generally by the equable furface of the forged bar, which is free from tranfverfe fiffures or cracks in the edges, and by a clear, white, fmall-grained, or rather fibrous texture. Another kind is tough when it is heated, but brittle when it is cold. This is called *cold-fhort* iron, and is generally known by a texture confifting of large, fhining plates, without any fibres. It is lefs liable to ruft than other iron. A third kind of iron, called *red-fhort*, is brittle when hot, and malleable when cold. On the furface and edges of the bars of this kind of iron, tranfverfe cracks or fiffures may be feen; and its internal color is dull and dark. It is very liable to ruft. Laftly, fome iron is brittle both when hot and when cold.

Moft authors, agree that the red-fhort quality of iron proceeds from fome fulphur or vitriolic acid being contained it, becaufe fulphur is known to produce this effect when added to iron; and becaufe the iron obtained from pyritous and other fulphurated ores has generally this quality.

The caufe of the cold-fhort quality of iron is not fo well afcertained. Some imagine that it proceeds from a mixture of arfenic or of antimony. But this opinion feems to be improbable, when we confider that thefe metallic fubftances may in a great meafure be diffipated by roafting, whereas the ores which yield a cold-fhort iron are injured by much roafting; that no arfenic or antimony are obfervable in moft, if in any, of thefe ores; and laftly, that thefe femi-metals would render the iron brittle both when hot and when cold. Cramer and other authors impute this vicious quality to a mixture of an unmetallic earth or vitreous matter, and affirm that it may be deftroyed by cementation with phlogifton, and by forging. And laftly, others afcribe the cold-fhort quality of iron to a defect of phlogifton, or, as Suedenborgius fays, of fulphur. To afcertain the caufes of the bad qualities of iron, and to difcover practicable remedies, are ftill defiderata in metallurgy.

In one bar frequently two or more different kinds of iron may be obferved, which run all along its whole length: and fcarcely a bar is ever found of entirely pure and homogeneous iron. This difference probably proceeds from the practice we have mentioned of mixing different kinds of ores together, in the fmelting; and alfo from that practice of mixing two or more pigs of caft iron of different qualities in the finery of thefe; by which means, the red-fhort and the cold-fhort qualities of the different kinds are not, as we have already remarked, mutually counteracted or deftroyed by each other, but each of thefe qualities is diminifhed in the mixed mafs of iron, as much as this

contained in all these compounds is rendered perfectly miscible with water by means of the saline matter, and it is consequently in a state truly saponaceous.

this mass is larger than the part of the mass originally possessed of that quality: That is, if equal parts of red-short and of cold-short iron be mixed together; the mixed mass will be only half as red-short as the former part, and half as cold-short as the latter. For these different kinds of iron seem as if they were only capable of being interwoven and diffused through each other, but not of being intimately united or combined.

Of the SMELTING *of* TIN-ORES.

The tin-ores commonly smelted are those which consist of calx of tin combined with calx of arsenic and sometimes with calx of iron. These are either pure, as the tin-grains, or intermixed with spars, stones, pyrites, ores of copper, iron, or of other metals.

The impure ores must be *cleansed* as much as is possible from all heterogeneous matters. This cleansing is more necessary in ores of tin than of any other metal, because in the smelting of tin-ores a less intense heat must be given than is sufficient for the scorification of earthy matters, lest the tin be calcined. Tin-ores previously bruised may be cleansed by washing, for which operation their great weight and hardness render them well adapted. If they be intermixed with very hard stones or ferruginous ores, a slight roasting will render these impure matters more friable, and consequently fitter to be separated from the tin-ores. Sometimes these operations, the roasting, contusion, and lotion, must be repeated. By roasting, the ferruginous particles are so far revived, that they may be separated by magnets.

The ore, thus cleansed from adhering heterogeneous matters, is to be *roasted* in an oven or reverberatory furnace with a fire rather intense than long continued, during which it must be frequently stirred to prevents its fusion. By this operation, the arsenic is expelled, and in some works is collected in chambers built purposely above the calcining furnace.

Lastly, the ore cleansed and roasted is to be *fused*, and reduced to a metallic state. In this fusion, attention must be given to the following particulars. 1. No more heat is to be applied than is sufficient for the reduction of the ore, because this metal is fusible with very little heat, and is very easily calcinable. 2. To prevent this calcination of the reduced metal, a larger quantity of charcoal is used in this than in most other fusions. 3. The scoria must be frequently removed, lest some of the tin should be involved in it, and the melted metal must be covered with charcoal powder to prevent the calcination of its surface. 4. No flux or other substance, excepting the scoria of former smeltings which contains some tin, are to be added, to facilitate the fusion.

SMELTING *of* ORES *of* LEAD.

Ores of lead are either *pure*, that is, containing no mixture of other metal; or they are *mixed* with silver, copper, or pyrites. The methods of treating ores of lead containing silver and copper, are described in the articles SMELTING *of* ORES *of* SILVER and *of* COPPER; and in the former of these articles, an instance is given of the method of smelting the ore of Rammelsberg, which contains all these three metals.

Pure ores of lead, and those which contain so small a quantity only of silver as not to compensate for the expence of extracting the nobler metal, may be smelted in furnaces, and by operations similar to those used at Rammelsberg, or in the following methods. 1. From the lead-ore of *Willach* in *Carinthia*, a great part of the lead is obtained by a kind of *eliquation*, during the roasting of the ore. For this purpose, the ore is thrown upon several strata or layers of wood, placed in a calcining or reverberatory furnace. By kindling this wood, a great part of the lead flows out of the ore, through the layers of fuel, into a bason placed for its reception. The ore which is thus roasted is beat into smaller pieces, and exposed to a second operation similar to the former, by which more metal

We may also combine acids directly with oils, and thus may form artificially acid soaps. But these operations are difficult and exhibit many singular appearances,

metal is eliquated; and the remaining ore is afterwards ground, washed, and smelted in the ordinary method.

The lead of Willach is the purest of any known. Schlutter ascribes its great purity to the method used in extracting it, by which the most fusible, and consequently the purest part of the contained lead is separated from any less fusible metal which happens to be mixed with it, and which remains in the roasted ore. This method requires a very large quantity of wood.

2. In England, lead-ores are smelted either *upon a hearth*, or *in a reverberatory furnace*, called *a cupol*.

In the first of these methods, charcoal is employed as fuel, and the fire is excited by bellows. Small quantities of fuel and of ore are thrown alternately and frequently upon the hearth. The fusion is very quickly effected; and the lead flows from the hearth as fast as it is separated from the ore.

3. In the second method practised in England, pit-coal is used as fuel. The furnace is represented by *Fig.* 14. *and* 15. PLATE II. The ore is melted by means of the flame passing over its surface; its sulphur is burnt and dissipated, while the metal is separated from the scoria, and collected at the bottom of the furnace. When the ore is well cleansed and pure, no addition is requisite; but when it is mixed with calcareous or earthy matrix, a kind of fluor or fusible spar found in the mines is generally added to render the scoria more fluid, and thereby to assist the precipitation of the metal. When the fusion has been continued about eight hours, a passage in the side of the furnace is opened, through which the liquid lead flows into an iron cistern. But immediately before the lead is allowed to flow out of the furnace, the workmen throw upon the liquid mass a quantity of flaked quicklime, which renders the scoria so thick and tenacious, that it may be drawn out of the furnace by rakes. Schlutter mentions this addition of quicklime in the smelting of lead-ores in England, but thinks that it is intended to facilitate the fusion of the ore, whereas it really has a contrary effect, and is never added till near the end of the operation, when the scoria is to be raked from the surface of the metal.

Of the SMELTING *of* ORES *of* SEMIMETALS.

ANTIMONY is obtained by a kind of eliquation from the minerals containing it, as is described in the article ANTIMONY: and the regulus of antimony is procured from antimony, by the processes described in the same *article*, and in the article REGULUS *of* ANTIMONY.

ARSENIC, SAFFRE, and BISMUTH are obtained generally from one ore, namely, that called *cobalt*. The arsenic of the ore is separated by roasting, and adheres to the internal surface of a chimney, which is extended horizontally about two or three hundred feet in length, and in the sides of which are several doors, by means of which the arsenic, when the operation is finished, may be swept out and collected. These chimneys are generally bent, in a zig-zag direction, that they may better retard and stop the arsenical flowers. These flowers are of various colors, white, grey, red, yellow, according to the quantity of sulphur or other impurity with which they happen to be mixed. They are afterwards purified by repeated sublimations; while some alkaline or other substances are added to detain the sulphur, and to assist the purification.

In the same roasting of the ore by which the arsenic is expelled, the bismuth, or at least the greatest part of this semimetal which is contained in the ore, being very fusible, and having no disposition to unite with the regulus of cobalt, which remains in the ore, is separated by eliquation.

The remaining part of the roasted ore consists chiefly of calx of regulus of cobalt, which not being volatile, as the arsenic is, nor so easily fusible as bismuth is, has been neither volatilized nor melted. It contains also some bismuth, and a small quantity of arsenic, together with any silver or other fixed metal which happened to be contained in the ore. This roasted ore being reduced to a fine powder, and mixed with three or four times its weight of fine sand, is the powder

according to the state and nature of the acids and oils combined. Vitriolic and nitrous acids, especially when well concentrated, act so powerfully upon all drying, sweet, or essential oils, that they produce considerable alterations. Nitrous acid inflames them, or, when not sufficiently concentrated to produce this inflammation, it reduces them, as the vitriolic acid also does, into thick, resinous, and bituminous compounds. The action of these acids appears less strong upon the fat oils, which do not dry, and are capable of forming with them true acid soaps. But all these matters have been but superficially examined, and may be considered, by persons desirous of extending chemical knowledge, as a new subject.

DCXXXIV. SOAP (COMMON). Common soap is a combination of oil of olives with fixed alkali rendered caustic by quicklime. Soap may be made by several methods, which however all depend upon the

powder called *saffre* or *zaffre*. *See* SAFFRE. Or the roasted ore is sometimes fused with about thrice its quantity of pure sand and as much pure potash, by which a blue glass, called *smalt*, is produced (*see* SMALT), and a metallic mass, called *speiss*, is collected at the bottom of the vessel in which the matters are fused. The metallic mass or speiss is composed of very different substances, according to the contents of the ore and the methods of treating it. The matters which it contains at different times are, nickel, regulus of cobalt, bismuth, arsenic, sulphur, copper, and silver.

Bismuth is seldom procured from any other ores but that of cobalt. It might however be extracted from its proper ores, if a sufficient quantity of these was found, by the same method by which it is obtained from cobalt, namely, by eliquation.

MERCURY, when native and enveloped in much earthy or other matter, from which it cannot be separated merely by washing, is distilled either by ascent, or by descent. When it is mineralised by sulphur, that is, when it is contained in cinnabar, some intermediate substance, as quicklime, or iron, must be added in the distillation, to disengage it from the sulphur. *See* CINNABAR. The rich ore of Almaden in Spain is a cinnabar, with which a calcareous stone happens to be so blended, that no addition is required to disengage the mercury from the sulphur. The distillation is there performed in a furnace consisting of two cavities, one of which is placed above another. The lower cavity is the fire-place, and contains the fuel, resting upon a grate, through the bars of which the air enters, maintains the fire, and passes into a chimney, placed at one side of the fire-place immediately above the door through which fuel is to be introduced. The roof of this fire place, which is vaulted and pierced with several holes, is also the floor of the upper cavity. Into this upper cavity the mineral from which mercury is to be distilled is introduced, through a door in one of the sides of the furnace. In the opposite wall of this cavity are eight openings, all at the same height. To each of these openings is adapted a file of aludels connected and luted together, extending sixty feet in length. These aludels, which are earthen vessels open at each end, and wider in the middle than at either extremity, (*see* ALUDEL *and* PLATE I.) are supported upon an inclined terras; and the aludel of each file, that is most distant from the furnace, terminates in a chamber built of bricks, which has two doors, and two chimneys.

When the upper cavity is filled sufficiently with the mineral, a fire is made below, which is continued during twelve or fourteen hours. The heat is communicated through the holes of the vaulted roof of the fire-place to the mineral in the upper cavity, by which means the mercury is volatilised, and its vapor passes into the aludels, where much of it is condensed, and the rest is discharged into the brick-chamber, in which it circulates till it also is condensed. If any air or smoke passes through the aludels along with the vapor of the mercury, they escape through the two chimneys of the chamber. Three days after the operation, when the apparatus is sufficiently cooled, the aludels are unluted, and the doors of the chamber are opened, and the mercury is collected.

same

ſame principle. The ſoap which is uſed in medicine is made without heat in the following manner.

One part of quicklime and two parts of good Spaniſh ſoda are boiled together, during a ſhort time, with twelve times as much water, in an iron caldron. This lixivium is to be filtered, and evaporated by heat, till a phiol which is capable of containing an ounce of water, ſhall contain an ounce and three gros of this concentrated lixivium. One part of this lixivium is to be mixed with two parts of oil of olives, or of ſweet almonds, in a glaſs or ſtone-ware veſſel. The mixture is to be ſtirred from time to time with an iron ſpatula, or with a peſtle, and it ſoons becomes thick and white. The combination is gradually compleated, and in ſeven or eight days a very white and firm ſoap is obtained.

Soap is made with heat in manufactures where large quantities of it are prepared. A lixivium of quicklime and ſoda is made, but is leſs concentrated than that above deſcribed, and only ſo much that it can ſuſtain a freſh egg. A part of this lixivium is to be even diluted, and mixed with an equal weight of oil of olives. The mixture is to be put on a gentle fire, and agitated, that the union may be accelerated. When the mixture begins to unite well, the reſt of the lixivium is to be added to it, and the whole is to be digeſted with a very gentle heat, till the ſoap be completely made. A trial is to be made of it to examine whether the juſt proportion of oil and alkali has been obſerved. Good ſoap of this kind ought to be firm and very white when cold, not ſubject to become moiſt by expoſure to air, and entirely miſcible with pure water, to which it communicates a milky appearance, but without any drops of oil floating on the ſurface. When the ſoap has not theſe qualities, the combination has not been well made, or the quantity of ſalt or of oil is too great, which faults muſt be corrected.

In ſoft or liquid ſoaps, green or black ſoaps, cheaper oils are employed, as oil of nuts, of hemp, of fiſh, &c. Theſe ſoaps, excepting in conſiſtence, are not eſſentially different from white ſoap.

Any fixed alkalis are much diſpoſed to unite with oils that are not volatile, both vegetable and animal, ſince this union can be made even without heat. The compound reſulting from this union partakes at the ſame time of the properties of oil, and of alkali; but theſe properties are modified and tempered by each other, according to the general rule of combinations. Alkali formed into ſoap has not nearly the ſame acrimony as when it is pure; it is even deprived of almoſt all its cauſticity, and its other ſaline alkaline properties are almoſt entirely aboliſhed. The ſame oil contained in ſoap is leſs combuſtible than when pure, from its union with the alkali, which is an uninflammable body. It is miſcible or even ſoluble in water to a certain degree, by means of the alkali. Soap is entirely ſoluble in ſpirit of wine, and ſtill better in aqua vitæ ſharpened by a little alkaline ſalt, according to an obſervation of Mr. Geoffroy.

When oil unites with alkali in the formation of ſoap, it is little altered in the connexion of its principles, for it may be ſeparated from the alkali by decompoſing ſoap with any acid, and may be obtained nearly in its original ſtate. By the accurate inveſtigation that Mr. Geoffroy has made of ſoap, by decompoſing it thus by means of an acid, he found that two ounces of this compound conſiſt of one ounce, three gros and one ſcruple of oil, one gros and a ſcruple of

marine alkali deprived of all oil and moisture, or twice the quantity of this salt containing the water of its cryſtallization, and, laſtly, two gros and four grains of water. This latter quantity of water is nevertheleſs variable, according to the condition of the ſoap; for it may be much more or much leſs dry.

Concerning the decompoſition of ſoap by means of acids we muſt obſerve, firſt, that all acids, even the weakeſt vegetable acids, may occaſion this decompoſition, becauſe every one of them has a greater affinity than oil with fixed alkali. Secondly, theſe acids, even when united with any baſis, excepting a fixed alkali, or the inflammable principle, are capable of occaſioning the ſame decompoſition; whence all ammoniacal ſalts, all ſalts with baſis of earth, and all thoſe with metallic baſes, are capable of decompoſing ſoap, in the ſame manner as diſengaged acids are; with this difference, that the oil ſeparated from the fixed alkali, by the acid of theſe ſalts, may unite more or leſs intimately with the ſubſtance which was the baſis of the neutral ſalt employed for the decompoſition.

Soap may alſo be decompoſed by diſtillation, as Lemery has done. When firſt expoſed to fire, it yields a phlegm called by him a ſpirit; which nevertheleſs is neither acid nor alkaline, but ſome water which enters into the compoſition of ſoap. It becomes more and more colored and empyreumatic as the fire is encreaſed, which ſhews that it contains the moſt ſubtle part of the oil. It ſeems even to raiſe along with it, by help of the oil and action of the fire, a ſmall part of the alkali of the ſoap: for, as the ſame chemiſt obſerves, it occaſions a precipitate in a ſolution of corroſive ſublimate. After this phlegm, the oil riſes altered, preciſely as if it had been diſtilled from quicklime, that is, empyreumatic, ſoluble in ſpirit of wine, at firſt ſufficiently ſubtle and afterwards thicker. An alkaline reſiduous coal remains in the retort, conſiſting chiefly of the mineral alkali contained in the ſoap, and which may be diſengaged from the coal by calcination in an open fire, and obtained in its pure ſtate.

As all oils contain an acid more or leſs combined, which may alſo be more or leſs diſengaged by the oil becoming rancid, by the action of heat, or by combination with other bodies, probably a portion of the alkali of the ſoap is ſaturated with the acid of the oil, eſpecially after the diſtillation of the ſoap. But this matter has not been ſo well examined, that we can affirm any thing concerning it.

Alkaline ſoaps are very uſeful in many arts and trades, and alſo in chemiſtry and medicine. Their principal utility conſiſts in a deterſive quality that they receive from their alkali, which, although it is in ſome meaſure ſaturated with oil, is yet capable of acting upon oily matters, and of rendering them ſaponaceous and miſcible with water. Hence ſoap is very uſeful to cleanſe any ſubſtances from all fat matters with which they happen to be ſoiled. Soap is therefore daily uſed for the waſhing and whitening of linen, for the cleanſing of woolen-cloths from oil, and for whitening ſilk and freeing it from the reſinous varniſh with which it is naturally covered. Pure alkaline lixiviums being capable of diſſolving oils more effectually than ſoap, might be employed for the ſame purpoſes; but when this activity is not mitigated by oil as it is in ſoap, they are capable of altering and even of deſtroying entirely by their cauſticity moſt ſubſtances, eſpecially animal matters, as ſilk, wool, and others: whereas ſoap cleanſes

cleanſes from oil almoſt as effectually as pure alkali, without danger of altering or deſtroying, which renders it very uſeful.

Soap furniſhes medicine with a very efficacious and valuable remedy. Til lately, that Mrs. Stephen's lithontriptic remedy has been publiſhed, phyſicians attended little to the medicinal qualities of ſoap. They ſoon found that ſoap, which is the principal ingredient of this famous remedy, is alſo the only one which has any real efficacy. And although this remedy has been found to be inſufficient to diſſolve moſt ſtones of the bladder, yet experience and obſervation have ſufficiently evinced that it can prevent the enlargement, or even the formation, of ſtones in perſons diſpoſed to that diſeaſe; that it can, in a word, attenuate, divide, and expel the ſtoney particles generated in the urinary paſſages, and which are the firſt materials of the ſtone. And accordingly ſoap is frequently uſed ſucceſsfully in theſe caſes. When ſoap was once diſcovered to act ſenſibly on the glue or binding ſubſtance of that urinary ſand, gravel, and even of ſome ſtones, it was naturally ſuppoſed to be capable of acting more powerfully on other thickened matters, which are too frequent cauſes of many obſtinate diſeaſes. Theſe conſiderations have induced the beſt practitioners to preſcribe ſoap as a reſolving, aperitive, and deobſtruent remedy; and we are certain that it has been employed as ſuch with great ſucceſs.

From the properties of ſoap we may know that it muſt be a very effectual and convenient anti-acid. It abſorbs acids as powerfully as pure alkalis and abſorbent earths, without having the caufticity of the former, and without oppreſſing the ſtomach by its weight, like the latter.

Laſtly, we may perceive that ſoap muſt be one of the beſt of all antidotes to ſtop quickly, and with the leaſt inconvenience, the bad effects of acid corroſive poiſons, as aqua fortis, corroſive ſublimate, &c.

DCXXXV. SOAP (STARKEY's). This preparation is a combination of fixed vegetable alkali with eſſential oil of turpentine. It is named from the inventor, a chemiſt, called Starkey, who endeavoring to reſolve the problem of the volatiliſation of ſalt of tartar, combined that alkali with ſeveral ſubſtances, and particularly with oil of turpentine, and remarked that from this latter mixture a ſaponaceous compound was formed, which has been ſuppoſed to poſſeſs many medicinal virtues. It enters into the compoſition of pills, named alſo from Starkey. The belief of its good qualities has induced perſons to continue the preparation of this ſoap, and to endeavor, but without ſucceſs, to improve the proceſs.

Although fixed alkalis are not abſolutely inactive upon eſſential oils, they cannot however unite as eaſily with theſe, as with ſweet oils, which are not volatile. If we attempt to combine any eſſential oil, and particularly oil of turpentine, with liquid fixed alkali, as in the preparation of ordinary ſoap, we ſhall ſoon find that theſe two ſubſtances cannot unite, or only imperfectly, and in long time. Starkey found no other expedient for the preparation of his ſoap than time and patience. His method, which is perhaps the beſt of all, conſiſts in putting dry alkali into a matraſs, and pouring upon it eſſential oil of turpentine to a height equal to the breadth of two or three fingers. In a long time the combination was compleated In five or ſix months a part of the alkali and oil are thus combined together, and form a ſort of white ſaponaceous compound. This ſoap

muſt be ſeparated from the mixture, and more of it will be afterwards formed in the ſame manner.

Shorter methods have been ſearched for the preparation of this ſoap, by ſeveral chemiſts; and amongſt theſe is the illuſtrious Stahl; who conſidering water as part of the combination of every ſoap, and even that it is a medium by which the ſalt and oil are united together, directs that after having mixed oil of turpentine with very hot alkali, and having ſhook them together, this mixture ſhould be expoſed in a moiſt place, that all the portion of alkali which does not unite with the oil may deliquiate, and be ſeparated from the part of the mixture that is combined; that this alkali ſhould then be dried, and new oil poured upon it, as at firſt; and, laſtly, that this method ſhould be continued till the whole be reduced into ſoap; and thus the operation will, as he affirms, be greatly ſhortened. Nevertheleſs, later chemiſts, not ſatisfied with this method of Stahl, have endeavoured to ſimplify ſtill more this operation. Mr. Rouelle the younger has publiſhed in the *Journal de Medicine*, that he has diſcovered a more expeditious method than all thoſe hitherto known for the preparation of this ſoap. Mr. Beaumé has alſo publiſhed in the *Gazette de Medicine* a method of making it in a few hours. It conſiſts in triturating, during a long time, alkaline ſalt upon a porphyry, and in adding to this ſalt, during the trituration, oil of turpentine. According to this able chemiſt, the thick reſinous part only of this oil can truly combine with fixed alkali: and this combination is effected only while the more volatile and attenuated part of the oil is diſſipated. For which reaſon, according to him, a very great quantity of oil of turpentine is requiſite for the formation of Starkey's ſoap, which quantity of oil is indeterminate, as, the more volatile and ethereal it is, the more of it is required; and alſo the trituration upon the porphyry, by promoting the evaporation of the ſubtle part of the oil, accelerates conſiderably the operation of Starkey's ſoap.

Another artiſt ſays, in the *Gazette de Medicine*, that the operation may be much abridged, by adding to the new mixture a certain quantity of this ſoap ready made; which correſponds with Mr. Beaumé's opinion. Laſtly, Mr. Beaumé has found, that the addition of a little turpentine, or of ordinary ſoap, conſiderably abridges the operation; and this alſo confirms his opinion, which ſeems to be very probable. We do not mean to blame the zeal of theſe chemiſts in making ſo many attempts to find a method of preparing this ſoap quickly, but we confeſs that the importance of the object does not ſeem adequate to their trouble. For, in fact, what does it ſignify whether this ſoap, not uſed in the arts, and but little in medicine, be quickly or ſlowly made? The eſſential point is not that it be quickly, but well done.

And to ſpeak our ſentiments freely, this preparation ſeems to be uncertain and ill-choſen. For, beſides that the true ſoap of Starkey, that is, the intimate combination of ethereal oil of turpentine with fixed alkali, according to the uſual idea of it, is a thing probably impoſſible, we believe that we may affirm, that the ſaponaceous compounds obtained by any method of mixing oil of turpentine with fixed alkali do not long remain in the ſame ſtate, and by time neceſſarily undergo perpetual alterations.

To be fully convinced of this truth, we may compare together not only theſe ſoaps made by different proceſſes, but alſo the ſame ſoap, a longer or a ſhorter time

time after it has been made, and we ſhall find conſiderable differences in their color, ſmell, and conſiſtence. We ſhall find that thoſe deliquiate, and are partly reſolved into liquor by the air, that have been made with a too ethereal oil, which is incapable of ſaturating well the fixed alkali; that others acquire by time a pitchy, yellowiſh, ſemi-tranſparent and reſinous appearance, which contain too large a quantity of thick reſiduum of oil of turpentine. Thoſe ſoaps which ſeem to be the beſt made, which contain a proper quantity of oil of turpentine, which are neither too ethereal nor too thick, preſerve longer their white color and the conſiſtence of true ſoap: But they nevertheleſs participate more or leſs of the faults we have mentioned. Laſtly, all theſe ſoaps are liable to contain a conſiderable quantity of a ſort of neutral ſalt, formed by the acid of the oil of turpentine, united with a part of the alkali of the ſoap. This ſalt cryſtallizes upon the ſurface, and even within the ſoap, which in time becomes quite penetrated and ſtuck all over with a ſaline effloreſcence. Theſe bad qualities and alterations of Starkey's ſoap cannnot be avoided by any method, as they depend on the nature of eſſential oils, which we cannot change. Theſe ſoaps are known to contain a volatile and ſuperficially combined acid, which unfolds itſelf more and more, or which is engaged more intimately with a portion of oil, to which it gives a thicker conſiſtence. We are no leſs certain that the moſt ethereal part of eſſential oils, or their ſpiritus rector, is ſo volatile, that however attentive we may be to preſerve it, it will gradually diſſipate in time: in a word, we know from experience, that all eſſential oils are drying, and are much more ſpontaneouſly alterable than any others; and that theſe ſpontaneous alterations cannot be prevented by the imperfect combination which they are capable of forming with an alkali. On the contrary, this alkali, by abſorbing their acid, and by facilitating the diſſipation of their ethereal part, with which the alkali is not capable of forming a true union, can only haſten the alterations to which the oil is naturally diſpoſed.

From all this we ought to conclude, that Starkey's ſoap is a difficult, uncertain, variable preparation, which is continually changing its nature, and conſequently its medicinal virtues. This latter inconvenience, although it were the only one, would be ſufficient to make us reject this preparation. And therefore, if, as is probable, a ſaponaceous ſubſtance, partaking of the properties of fixed alkali and of an eſſential oil, would be uſeful in medicine; ordinary ſoap, incorporated extemporaneouſly with any quantity of eſſential oil which ſhall be judged proper, might be ſubſtituted inſtead of Starkey's ſoap. *See* OILS (ESSENTIAL).

DCXXXVI. S O A P-R O C K, *or* SOAP-STONE. *See* STEATITES.

DCXXXVII. S O D A. *(r)*

DCXXXVIII. S O L U T I O N. Solution conſiſts in an union formed by the integrant parts of one body with the integrant parts of another body of a different nature; and as a new compound is the reſult of this union, we hence ſee that ſolution is nothing elſe than the act of combination.

As the integrant parts of one body cannot unite with thoſe of another, while

(r) Soda is a name given to the maritime plant *kali*, from the aſhes of which a conſiderable quantity of mineral alkali may be obtained; and alſo to the aſhes themſelves, or to an impure alkaline ſalt extracted from theſe. *See* KALI, *and* ALKALI (MINERAL).

they

they adhere together; therefore solution cannot be made till the aggregation of one of the two bodies at least is broken. And as bodies whose aggregation is broken are necessarily in a state of fluidity or of vapors, an axiom has been formed, *Corpora non agunt nisi sint fluida*, or, Bodies do not act unless they be fluid.

The two bodies which unite in solution are usually distinguished by two different names. That body is generally called the *solvent* which by its fluidity or acrimony appears to be active; and the body which from its want of taste or from its solidity appears to be altogether passive, is said to be *dissolved*. Thus, for example, when metal or marble is dissolved in aqua fortis, these solid bodies are considered as being *dissolved*, and aqua fortis as the *solvent*. But these expressions ought not to be taken literally, for they would give a very false idea of what really happens in solution. On the contrary, we are certain that any two bodies, which unite together in solution, reciprocally exercise their action one upon another, and that the union which results from it is only the effect of the mutual tendency which they have to each other: that thus, in the examples mentioned, the marble and metal act as much upon the nitrous acid as this does upon them; and that, if they differ in this respect, that body, whose specific gravity is greatest, acts most strongly. Mr. Gellert, considering the thing in this point of view, affects to represent as *solvents* the bodies which are generally considered as *dissolved*, and says, for instance, that *sand dissolves alkali*. Provided that we understand that the action of the combining bodies is mutual, it signifies little that we name the one *solvent*, and the other the body *dissolved*: and even as the word *solution*, taken in its most proper signification, expresses the separation of the integrant parts of a body, we seem to speak more clearly and accurately when we call that body the *solvent*, whose integrant parts are already separated before the solution, and that the *body dissolved* whose integrant parts are only disunited during the act of solution.

As the solution cannot be effected unless one of the two bodies at least be fluid, and as solid bodies only become fluid by the interposition of the parts of some other fluid, such as water and watery liquors, or fire, hence solution may be made either by the *humid* or by the *dry way*. The solutions in which the integrant parts of one of the two bodies, or of both, are distributed in an aqueous fluid, as, for instance, those of acids, are *solutions by the humid way*; and those solutions in which one or both bodies are rendered fluid by fire, as in vitrification, and in allays of metals with each other, are *solutions in the dry way*.

The solution of bodies is not perfect, unless each of the integrant parts of one body are united to one of the integrant parts of another. Hence if one of the two bodies be transparent, we ought to have, after the mutual solution, a transparent compound, as happens in the solutions of calcareous stones and acids, and of those of earths by alkalis. As therefore the solution of soap in water is always a little opake and milky, it ought not to be considered as complete. The same may be said of glasses that are not perfectly transparent. Their want of transparency always proceeds from the parts of the sand or flint not having been sufficiently dissolved by the salt, or from their containing some

refractory

refractory matters, such as certain metallic calxes, particularly calx of tin, which resist the action of salts.

As the solution of two bodies by one another can only be effected by the attraction or tendency which their integrant parts have to each other, hence, after the solution, these parts are found to adhere together: hence also heavy bodies may be suspended in the thinnest and lightest liquids, when they are truly dissolved by each other. For instance, corrosive sublimate, which is very heavy, may be suspended by spirit of wine, which keeps it dissolved, altho' this liquor be very light. *See* COMPOSITION *and* COMBINATION.

DCXXXIX. SOOT. Soot is a collection of substances formed by the matter of the flame of inflammable bodies, but which have escaped combustion, from not having sufficient contact with the air. This matter, which fixes itself to the internal surface of chimneys, is always of a black color, more or less brownish. This color it receives from an oil that is burnt, and half reduced to the state of coal.

As all inflammable bodies undergo a total decomposition during their inflammation, all the volatile principles which they contain, and even a part of the fixed principles, by means of those which are volatile, are raised in vapors, some part of which burns with flame, is totally dissipated and destroyed, and another part is sublimed and adheres to the first cold bodies which it meets.

Soot is, as we have now observed, the portion of flame which is reduced to black smoke, and which has not been inflamed from want of sufficient contact with air. For if the vapors exhaling from an inflammable body strongly heated were so rarefied that each of their parts should be altogether surrounded by air, they would all burn with flame, and then we should have no smoke or soot, or at least this soot would not be black, and would contain nothing inflammable. For which reason, the greater quantity of air is admitted amongst bodies which burn with flame, the less smoke and soot we have; and also, the soot proceeding even from bodies of the same kind must be very different according to the manner in which they are burnt. In general, we can say nothing that will be constantly applicable to the nature and principles of soot, as its differences arise not only from the causes abovementioned, but also from the nature of the inflammable substances which produce it. Thus vegetables, from which little or no volatile alkali is obtained, must furnish a soot different from that of animal matters; and the soot of a pure oil must be different from that of a plant containing all its principles. But these differences have not yet been observed, because chemists have not attended to this subject.

We know only that the ordinary soot of chimneys has an acrid, bitter, empyreumatic, and disagreeable taste; that water can extract from it a dusky-colored matter, which shews that it contains saline, oily, saponaceous parts; that it is capable of being again burnt very vividly and with much flame, as when chimneys are set on fire.

If this soot be distilled in a retort, we obtain from it phlegm, volatile alkali, partly concrete and partly liquid, a black empyreumatic oil, and in the retort much coal remains, from which fixed alkali may be extracted by incineration and lixiviation. Some acid also may possibly be obtainable from certain soots; and

and generally towards the end of the diſtillation, when the heat is ſtrong, a little ſal ammoniac is ſublimed.

As every ſoot, even that which proceeds from vegetable matters, contains a good deal of volatile alkali, we may infer, that the principles of vegetables ſuffer, by combuſtion in an open fire, changes ſimilar to thoſe occaſioned by putrefaction. Beſides, the quantity of fixed coal which remains after the diſtillation of ſoot, and which furniſhes a fixed alkali, together with much earth, by incineration, ſhows that a very conſiderable quantity of the fixed principles of inflammable bodies is carried off, and even raiſed to a great height, by means of their combuſtion with flame: but, as we have ſaid, ſoots are very different; and the matter is but little known, and requires further reſearches.

DCXL. S O R R E L. (*s*)

DCXLI. S P A R. Naturaliſts and chemiſts have given this name to certain cryſtallized ſtones, more or leſs tranſparent, which generally do not ſtrike fire with ſteel, and which are found plentifully within the earth, but more eſpecially in mines of metals.

Under this general name many ſtones are comprehended; becauſe they have the general properties we have mentioned, and becauſe they reſemble each other by the form of their cryſtallization, in which we always perceive ſhining plates, like mirrors; but ſome of theſe ſtones are very different from others.

Some ſpars are entirely ſoluble with effervеſcence in acids, forming ſelenites with vitriolic acid, deliqueſcent ſalts with nitrous and marine acids, and convertible into quicklime by calcination. Theſe ſtones are juſtly called *calcareous ſpars.*

Others, although entirely ſimilar to theſe in appearance, do not effervеſce with acids, are calcinable as gypſum and ſelenites are, and are, in fact, true ſelenites compoſed of vitriolic acid and calcareous earths. Theſe ſpars are eſſentially different from the former, and are *gypſeous* or *ſelenitic ſpars.*

Other ſpars are neither calcareous nor ſelenitic, do not loſe their tranſparency in the fire, and ſeem to be of the nature of *talc.*

Laſtly, a kind of ſtone, cryſtallized in mirror-like plates like a true ſpar, is almoſt opake, is indiſſoluble by acids, and is ſo much harder than all other ſpars as to be capable of ſtriking fire with ſteel. This ſtone is fuſible without addition, by the action of a violent fire, into a ſemi-tranſparent white matter. This ſeems to be the kind that Mr. Wallerius, Mr. Pott, and other German authors, call *fuſible ſpars.* They alſo mention another ſpar which is compact, breaks like glaſs, and melts without addition. From the deſcriptions given by moſt authors we cannot eaſily diſcover what they mean by fuſible ſpar, and by *quartz-ſpar.* Theſe matters have not yet been ſufficiently examined.

From the properties of all the ſubſtances called ſpars we may conjecture, that they are ſtones of all kinds, very different from each other, which being formed in metallic grounds, have contracted, either by the mixture of ſome metallic

(*s*) SORREL. The leaves of this plant contain an acid ſalt which may be obtained from the expreſſed juice by cryſtalliſation. From twenty pounds of freſh ſorrel-leaves Neuman expreſſed ſix pounds of juice, from which two ounces, two drams and one ſcruple of cryſtalliſed ſalt, together with two ounces and ſix drams of an impure ſaline maſs, were obtained. *See* SALT (ESSENTIAL) *of* SORREL.

earths,

earths, or even by a metalliſation begun in their own earth, ſome properties common to all, or, at leaſt, to the greateſt number.

Theſe properties are, 1. A certain form of ſhining laminæ in their cryſtallization, which appears even in thoſe, the figure of whoſe cryſtals ſeems leaſt diſpoſed to receive this form, as in thoſe which are ſtriated; for ſparry laminæ are diſtinguiſhable at the extremities of the ſtriæ, or bundles of ſtriæ, of which theſe ſpars are compoſed.

2. A greater ſpecific gravity than of all other ſtones. Some ſpars, eſpecially thoſe called *heavy ſpars*, are ſo very heavy, that they come near in this reſpect to metals.

3. A greater fuſibility than of other ſtones; for, beſides thoſe ſpars which are fuſible without addition, the mixture of ſpars facilitates the fuſion of moſt other earths and ſtones, and they are accordingly uſed as fluxes in the ſmelting of moſt metallic ores. Probably for this reaſon theſe ſtones have been called *fluors* by many mineralogiſts and metallurgiſts.

Laſtly, many ſpars are found colored by metallic principles, and imitate the colors of the ſeveral precious ſtones, although they are leſs beautiful and vivid.

We ſhall not enter into a more particular detail concerning ſpars, becauſe what is further known about them rather belongs to natural hiſtory than to chemiſtry; beſides that our knowledge of ſpars is very indiſtinct. (*t*)

(*t*) Spars. This name is given to many ſtones of different properties and appearances, which do not poſſeſs conſtantly any one common character or mark by which they may be certainly diſtinguiſhed from other ſtones. In general, we may obſerve, that they are moſt frequently found in mines, and that they generally conſiſt of ſmooth and ſhining plates or laminæ; that ſome are tranſparent, and others opake; that ſome are colorleſs, and others are colored; that they are cryſtallized in various determinate figures, or poſſeſs no determinate ſhape; and, laſtly, that they differ ſo much in hardneſs, denſity, degree of fuſibility, and in their moſt eſſential chemical properties, that they cannot be conſidered as forming a diſtinct claſs of foſſil ſubſtances. We need not wonder, therefore, that authors, eſpecially thoſe who have not been much accuſtomed to the examination of foſſil bodies, ſhould have given very confuſed and indiſtinct deſcriptions of ſpars. Many of them have not been ſufficiently examined; but thoſe, of which we have acquired ſome knowledge, we ſhall endeavor to diſtinguiſh into their ſeveral different kinds, and deſcribe more diſtinctly than is done in the preceding article.

The ſeveral ſtones to which the name of ſpar has been given are, the *calcareous*, the *gypſeous*, the *fuſible ſpars*, and *felt ſpar*.

1. *Calcareous ſpars* are ſoft, heavy ſtones, which have the common chemical properties of calcareous earth. Their texture is laminated. Some of them have no determinate figure, and others from their form are called *rhomboidal*. Some ſpars, called *dog's tooth-ſpar*, have a pyramidal figure; but when theſe are broken, their fragments ſhow that they alſo conſiſt of rhomboidal particles.

Some rhomboidal ſpars are tranſparent, others are opake; ſome are colorleſs, and others are colored; laſtly, ſome of them have a ſingular property of refracting doubly the rays of light which paſs through them, and thereby of repreſenting any object, as, for inſtance, the letters of a book, ſeen through it, double. This ſpar has been called *iſland cryſtal*, or *refracting ſpar*. Its figure is that of an oblique parallelopiped, contained within ſix parallelogram ſides and eight ſolid angles. Each of the obtuſe angles of the parallelograms is 101 degrees and 52 minutes; and each of the acute angles is 78 degrees and 8 minutes. Theſe are the dimenſions given by Sir Iſaac Newton of the angles of the ſides of the refracting ſpar; and I have found them to correſpond exactly with thoſe which I have ſeen.

Calcareous ſpars may be diſtinguiſhed from others by effervеſcing with acids.

2. *Gypſeous or ſelenitic ſpars.* Theſe are gypſeous

DCXLII. S P E L T E R. Zinc is sometimes so called. *See* ZINC.

DCXLIII. S P E R M A - C E T I. (*u*)

DCXLIV. S P I R I T. The name of spirit is given in general to all liquors obtained from substances by distillation. Spirits are of three principal kinds, namely, *inflammable spirits*, *acid spirits*, and *alkaline spirits*.

The class of inflammable spirits includes the most volatile and thinnest part of essential oils; the principle of smell, or the *spiritus rector* of plants; and *ardent spirits*, or the spirit obtained from wine, beer, and all liquors which have undergone the *spirituous fermentation*.

In the second class are all acids obtained by distillation of minerals, vegetables, and of animals. Such are, 1. the acids of sulphur, vitriol, alum, all which are the same acid, namely, the vitriolic, and the acids of nitre and of common salt. They are called *spirit of sulphur*, *spirit of vitriol*, *spirit of nitre*, &c. without specifying that they are acids. 2. The acids of *vinegar*, and of all liquors which have undergone the *acetous fermentation*, and the acids obtained in the distillation of vegetables, and of certain animals, as flies, ants, &c. These spirits are commonly called *acid spirits*, as the *acid spirit of guiacum*, the *acid spirits of ants*, &c. because the substances which furnish them yield also spirits that are not acid.

gypseous earth, distinctly crystallized. The form of the crystals is rhomboidal. They are also called *selenites* and *glacies Mariæ*. Sometimes these spars assume other forms. They are very heavy. *See* SELENITES, *and* GLACIES MARIÆ.

3. *Fusible spars*, called also *fluors*. Under this name many stones are comprehended of different shapes, appearances, and perhaps properties. Their general properties are described under the article FLUOR. They are most frequently found in mines, and are much used to facilitate the fusion of ores. Several fluors acquire a phosphoric property by calcination with inflammable matters. Such is the *Bolognian stone*; and also other white, heavy, friable, fusible spars, as Mr. Margraaf found. This chemist discovered, by analysing the Bolognian stone, and other fusible spars capable of receiving a phosphoric quality, that they consist of a gypseous earth united with a small quantity of clay. He also found, that several fusible spars could not receive the phosphoric quality of the Bolognian stone. What the cause of this difference is, and whether they all consist of the same constituent parts as those analysed by Mr. Margraaf, has not yet been discovered. *See* FLUOR.

4. *Felt-spar*, *Spatum scintillans*. This stone differs from all the foregoing, in being so hard as to be capable of striking ignited sparks from steel. For which reason it is referred by Cronstedt to the siliceous class of earths, and is by him called *rhombic quartz*; because the particles of which it consists seem to be parallelopipeds, each of which is contained within six rhombic or rhomboidal sides. Its colors are various, white, grey, and red.

Several other fossil substances consist of large plates, and are therefore said to have a *sparry texture*. Such are some kinds of talk, of horn-blend, of quartz, of amianthus, and some calciform ores of metals.

(*u*) SPERMA-CETI is a white, flaky, unctuous substance, obtained from the heads of whales. It is altogether soluble in oils; but is not capable of being dissolved by caustic alkalis, and of forming soaps, as other oily matters may. By distillation it may be entirely raised, without leaving any residuum. From four ounces of sperma-ceti three ounces and a half of oil, and a drachm and a half of phlegm, were distilled. The oil distilled is not black, fetid, and empyreumatic, like that of other animal substances, but clear, yellowish, and of the consistence of butter. Sugar does not render sperma-ceti perfectly miscible with water: but this may be better done by means of yolks of eggs. *Neuman.*

Lastly,

Laſtly, in the third claſs are liquid volatile alkalis, obtained from ſal ammoniac, from all vegetable matters which have undergone a compleat putrefaction, and from all animal matters. They are generally called *ſpirits* only, without ſpecifying their alkaline quality. Thus we ſay, *volatile ſpirit of ſal ammoniac*, *ſpirit of hartſhorn*, &c. As ſome of theſe ſubſtances, particularly ſal ammoniac, contain alſo an acid which may be obtained from them we ought, when we mention this ſpirit, to ſpecify its acid quality, and to name it, for inſtance, *acid ſpirit of ſal ammoniac*.

DCXLV. SPIRIT (ARDENT). Ardent ſpirit, called alſo *ſpirit of wine*, becauſe it can be only obtained from ſubſtances which have undergone the vinous fermentation, is a very light, very volatile, very fluid liquor, perfectly white and limpid, and of a ſtrong, penetrating, agreeable taſte and ſmell.

This ſpirit may be eaſily inflamed, without being previouſly heated. Its flame is light, white in the center, blue at its edges, and not very luminous. It is not accompanied with any ſmoke or ſoot. It burns without noiſe, and without any ſuffocating or other vapors.

Spirit of wine perfectly pure, for of that I ſpeak, burns alſo entirely, with concurrence of free air, without leaving the leaſt veſtige of coal, or of any ſaline, earthy, or other reſiduum.

Although ſpirit of wine be altogether inflammable, it is nevertheleſs miſcible with water without any intermediate ſubſtance, and in all proportions, which is a ſpecific character of this liquor; for it is the only ſubſtance of the kind known which is poſſeſſed of theſe properties.

If ſpirit of wine be expoſed to heat in cloſe veſſels, it does not inflame, but is eaſily reduced into vapors which paſs in diſtillation. Theſe vapors, when collected, are entirely the ſame ſpirit of wine as before diſtillation, without having received any alteration or decompoſition, however frequently the operation may have been repeated.

Juncker ſays, that if ſpirit of wine be burnt in a tubulated retort, to which a large glaſs receiver has been adapted, it will be changed into a very ſubtle vapor, which condenſes in the receiver, and forms a liquor ſimilar to pure water.

Boerhaave affirms, that when the vapor of burning ſpirit of wine is collected by an apparatus of proper veſſels, it is nothing but very pure water.

The following are the principal properties of ſpirit of wine relatively to other ſubſtances.

It ſeems to have no ſenſible action upon earths, or upon metallic matters, nor even upon many neutral ſalts; but with acids, alkalis, and many oily ſubſtances it exhibits remarkable phenomena.

Spirit of wine unites with all acids; and by this union the acidity of theſe is diminiſhed. Accordingly, the acids thus combined with ſpirit of wine are called *dulcified acids*. *See* WATER *of* RABEL; SPIRIT *of* NITRE, *and* SPIRIT *of* SALT (DULCIFIED).

But when it is mixed in certain proportions with concentrated acids, and diſtilled, at leaſt, with moſt of them, it then receives from them, and produces upon them the following alterations.

First of all, ſome of it paſſes over dephlegmated as much as it can be without being eſſentially altered; afterwards it loſes part of the water eſſential to it; conſequently the nature of the remaining part is changed, and it is converted into a liquor, the properties of which ſhew, that it is as much approximated to the nature of oil as it is removed from that of ſpirit of wine. This liquor, which is very fluid and very volatile, is called *ether*, which is, according to what we have ſaid, a ſubſtance exactly intermediate betwixt ardent ſpirit and oil. *See* ETHER.

After this, the ſpirit of wine, or its mixture with acids, acquires all the characters of oil, or rather becomes a genuine oil.

Acids, on their ſide, receive from ſpirit of wine, eſpecially after the formation of ether, all the alterations which they uſually receive from oils with which they have been treated and diſtilled. *See* ETHER.

Very ſtrong and dephlegmated alkalis act ſingularly upon ſpirit of wine, and are even capable of decompoſing it, when aſſiſted by a certain degree of heat. They deprive it, firſt, of all its ſuperabundant water, then of the water it contains as a principle, and, laſtly, they reduce it to the condition of a true oil, without making it paſs, as acids do, through the intermediate ſtate of ether. *See* TINCTURE *of* SALT *of* TARTAR.

Spirit of wine is commonly conſidered as the ſolvent of oils and of oily matters; but properly it is the ſolvent only of one kind of oils. Theſe are the eſſential oils and their concretions, ſuch as balſams and reſins; all which ſpirit of wine can diſſolve. It attacks neither the fat oils nor the oily concretions analogous to them, as wax, butter, fat of animals, nor even certain ſubſtances which ſeem to partake more of the nature of true reſins, as copal and bitumens. *See* OILS *and* RESINS.

When ſpirit of wine keeps an oily matter diſſolved, it may be ſeparated by diſtillation, if the oily matter be not volatile, or by diluting the ſolution with a large quantity of water. This water, with which the ſpirit has a greater affinity than with oil, unites with it, and renders it incapable of keeping the oil diſſolved. Hence the oily matter ſeparates at firſt in very ſmall globules, which are diſperſed through the liquor, and give it the white appearance of an emulſion; and theſe globules afterwards collect, forming more conſiderable maſſes, by which the liquor is rendered very clear.

Theſe properties of ſpirit of wine are advantageouſly applied to extract the eſſential oils and reſins of vegetable matters.

Accordingly, by digeſting in ſpirit of wine aromatic plants, for inſtance, thyme, lavender, roſemary, &c. a ſpirituous liquor is obtained, impregnated with the principle of the ſmell, and with the eſſential oil of the plants. Theſe ſpirituous aromatic waters, made by infuſion, ſerve for ſeveral purpoſes in medicine. They are generally colored by a part of the extractive matter of the vegetables, which the ſpirit of wine alſo diſſolves, or by ſubſtances of different colors which reſide in the reſinous ſubſtance. They have hence been called *tinctures*. *See* TINCTURE.

By diſtillation is obtained from ſpirituous tinctures a ſpirit of wine much impregnated with the principle of ſmell, and with the thinneſt and moſt volatile part of the eſſential oils, but free from all extractive or coloring matter; becauſe theſe latter are not ſufficiently volatile to riſe with ſpirit of wine. This

ſpirit of wine is called by the general name *aromatic ſpirituous diſtilled water*, or only by the name of *water*, added to the name of the plant employed: hence the names of *lavender-water*, *roſemary-water*, &c. Waters are alſo made of ſeveral plants, and are diſtinguiſhed by particular names, as *vulnerary-water*, *imperial-water*, &c. Theſe waters are intended for medicine and for the toilette. We may find the details of theſe preparations in books on pharmacy, and particularly in *Mr. Beaumé's Elements of Pharmacy*.

When a tincture has been diſtilled, we may find at the bottom of the veſſel the reſinous and extractive part which the ſpirit of wine had diſſolved. Theſe ſubſtances have undergone ſcarcely any alteration, becauſe they have been expoſed only to a very mild heat. Theſe are extracts of plants made by ſpirit of wine. *See* EXTRACT.

If, inſtead of ſubjecting to diſtillation the ſpirituous tinctures of vegetables, they be diluted with a large quantity of water, the reſinous part may be very well obtained pure and ſeparate from the extractive part. This latter part being equally ſoluble in water as in ſpirit, remains diſſolved notwithſtanding the addition of water, while the former part ſeparates, as we have ſaid, and forms a reſinous maſs.

By this method are obtained the reſins of jalap, of ſcammony, of guiacum, and of many other vegetable matters; and theſe reſins, not having undergone the action of fire, are not altered, but remain in the ſame ſtate in which they exiſted in the vegetables.

Spirit of wine diſſolves alſo very well certain ſalts, as ſal ammoniac, corroſive ſublimate, ſedative ſalt, and perhaps many others which we do not know of; becauſe this matter has not been much examined: but this ſpirit has little or no action upon other ſalts, as common ſalt, Glauber's ſalt, nitre, concrete volatile alkali, &c. It does not diſſolve matters purely gummy and gelatinous, or, at leaſt, it diſſolves but a ſmall quantity of them; and as all theſe matters are very ſoluble in water, and as water has a ſtronger affinity with ſpirit of wine than it has with theſe matters, hence this ſpirit may be employed to ſeparate theſe matters from water. For this purpoſe we need only to add a good deal of the ſpirit of wine to the water, which keeps them diſſolved: the ſpirit then ſeizes the water, and obliges the gummy, gelatinous, and ſaline parts which it contained in ſolution to ſeparate from it. The reverſe of all this paſſes in the ſeparation of oily and reſinous ſubſtances from ſpirit of wine by means of water. Spirit of wine coagulates the whites of eggs and animal lymph, by ſeizing upon the water which they contain.

The ſame may be ſaid of the coagulum formed by mixing ſpirit of wine with concrete volatile alkali, diſſolved by the ſmalleſt poſſible quantity of water. This coagulum, which is formed ſuddenly upon the mixture of theſe two liquors, and which is known in chemiſtry by the name *Offa Helmontii*, is nothing elſe than a ſudden cryſtallization of volatile alkali, occaſioned by the addition of ſpirit of wine, which ſeizes the water in which that alkali was diſſolved. The ſame may be ſaid of the cryſtallization of all ſalts, which may be inſtantaneouſly effected by the means of ſpirit of wine. *See* CRYSTALLIZATION.

From what has been ſaid concerning the diſſolving power of ſpirit of wine, we may judge of its great utility in chemiſtry in extractions and ſeparations. It is particularly very uſeful in the analyſis of vegetables and animals by menſtruums.

ſtruums. By reflecting attentively on the properties of this ſolvent, many analyſes and ſeparations which tend to the progreſs and perfection of chemiſtry may be improved.

We ſhall finiſh this article by ſome reflexions on the nature of ſpirit of wine.

Stahl and moſt chemiſts believe, that ſpirit of wine is compoſed of a very attenuated and very light oil, intimately united by means of an acid with a larger quantity of water than that which enters as a principle in the combination of oil.

Juncker, on the contrary, appears to admit no other inflammable matter in ſpirit of wine than phlogiſton united with the aqueous principle by means of an acid.

Laſtly, Mr. Cartheuſer poſitively advances, that ſpirit of wine is compoſed of pure phlogiſton, not in an oily ſtate, but immediately united with the watery principle alone.

This diverſity of opinion amongſt the ableſt chemiſts proves, that the true principles of ſpirit of wine are not yet perfectly known. This proceeds from the difficulty of decompoſing it without an intermediate ſubſtance, and alſo from ſeveral phenomena, ſome of which ſeem to ſhew that it is not a true oil that enters as a principle into the compoſition of ſpirit of wine, but phlogiſton alone; while others ſeem to indicate the preſence of a true oil exiſting in the pureſt ſpirit of wine.

If we mix the beſt rectified ſpirit of wine with water, and if we allow it to evaporate ſlowly in open air, we ſhall find upon the ſurface of the water a certain quantity of oil; and we have ſeen above, that a true oil may be obtained from ſpirit of wine by treating it with acids.

But again, if we attend to the eſſential and fundamental properties of ſpirit of wine, to its perfect miſcibility with water, to its flame, which is not accompanied with any ſoot or ſmoke, to the impoſſibility of reducing it without addition to the ſtate of coal; laſtly, to this property, that when it is inflamed we obtain nothing from it but a matter which burns, and pure water; all which properties are not ſuitable to an oil properly ſo called, we muſt acknowledge, that not oil, but pure phlogiſton, is the inflammable principle of ſpirit of wine. We have reaſon to believe, that the oil which is ſeparated from ſpirit of wine by water is extraneous to it, and is only contained in ſpirit of wine, becauſe the means employed to purify this ſpirit are inſufficient to deprive it of all oily matter; and alſo, that the oil obtained from mixtures of ſpirit of wine with acids, is evidently an artificial oil, and produced in the operation, as we may ſee at the word Ether.

As ſpirit of wine contains a pure phlogiſton very much unfolded, and almoſt diſengaged, it acts upon the nervous ſyſtem, like all the ſubſtances which contain a very volatile and very attenuated inflammable principle. *See* Wine *and* Phlogiston. It is alſo very powerfully antiſeptic: hence it is very ſucceſsfully employed to preſerve from putrefaction matters ſuſceptible of it. It is uſed topically in gangrenes; and alſo for the preſervation of dead animals, or parts of animals.

See for the rectification and purification of ſpirit of wine, Rectification.

DCXLVI. SPIRIT *of* LIBAVIUS. *See* Liquor (Smoking).

DCXLVII. SPIRIT *of* NITRE. Spirit of nitre and nitrous acid are two names for the same thing. For its properties, *see* ACID (NITROUS). We shall here explain the manner of distilling it, or of decomposing nitre in order to obtain it.

Vitriolic acid, and several matters containing it, are intermediate substances employed for the separation of nitrous acid from the fixed alkali with which it is united in nitre; because, in general, the former of these two acids is stronger than the latter. In several ways nitrous acid may be obtained by distillation; which however are fundamentally the same, although they vary in some circumstances, according to the nature of the intermediate substance employed, and the required strength of the nitrous acid.

The most frequent method of distilling spirit of wine, especially in great works, is to employ clay as an intermediate substance. As this kind of earth contains vitriolic acid, it is very proper for decomposing nitre.

Two parts of dry and powdered clay are to be well mixed with one part of nitre. This mixture is to be put into an earthen-ware retort, placed in a reverberatory furnace. To this retort a receiver is to be fitted, which is to be well luted, and the distillation is to be promoted by a gradual heat, that is very gentle at first, and raised towards the end so much that the retort shall be very red-hot.

The distillers of aqua fortis use very few precautions, and accordingly their spirit is generally weak and impure. For, in the first place, they employ nitre of the first, or at most of the second boiling, which contains always much common salt. Hence the acid which they obtain is mixed with a considerable quantity of spirit of common salt. It is consequently a kind of aqua regia.

In the second place they do not dry well their clay, by which means their acid is weak; although they always keep apart the most watery part which passes first; this they call *dephlegmating it.*

Lastly, the lute which they use for joining their vessels is only earth formed into a paste with water, a part of which falls into the receiver, especially when they unlute the vessels, and renders the spirit of nitre turbid. But as almost all the aqua fortis which they make is for purposes in which the same accuracy is not required as in chemical operations, this aqua fortis is sufficiently good for the uses for which it is employed.

Distillers of aqua fortis do not use retorts, but stone-ware bottles, with short crooked-necks. The receivers are vessels exactly of the same form. Two rows of these vessels are disposed opposite to each other, in an oblong furnace called a *galley*; and a wood-fire is used for the distillation. The operation lasts twelve hours.

Very good, very pure, and even very stong spirit of nitre may be made by the method of the distillers of aqua fortis. For this purpose nitre of the third boiling must be employed, the vessels must be carefully luted with a fat lute composed of dry clay, pounded, sifted and formed into a paste, with a sufficient quantity of boiled linseed oil; lastly, the contained matter must be dephlegmated more than is usual, before the luting is applied. The distillers attend to all these things, when good spirit of nitre is required, and a sufficient price is given. We may observe that spirit of nitre is never so high colored and smoking, when distilled

diſtilled by means of clay, as when obtained by the other methods, although it may be equally ſtrong.

DCXLVIII. SPIRIT *of* NITRE (SMOKING). Two methods are uſed in chemical laboratories to obtain a very ſtrong and ſmoking ſpirit of nitre. The firſt is by means of martial vitriol, previouſly calcined till it becomes red-hot, that all the water of its cryſtallization may be expelled. Alſo, very pure nitre of the third or even fourth boiling muſt be well dried. Theſe two matters are to be pounded and carefully mixed together in equal proportions. They are then to be poured into a good earthen ware retort through a paper funnel, which paſſes into the belly of the retort, that none of the powder may adhere to the neck of it. The retort is placed in a reverberatory furnace, upon the bars of which is fixed an earthen diſh filled with ſand. To the retort a large glaſs balloon, in which is a ſmall hole, is to be fitted and luted with a fat lute. This lute is to be covered with a cloth ſoaked with another lute made of quicklime ſlaked in air, and formed into a thin paſte with whites of eggs. The whole luting apparatus is to be bound with a ſtring. Then the diſtillation is to be commenced with a very ſlow fire. The balloon will ſoon be filled with red vapors which are condenſed there, while another portion of ſpirit of nitre diſtills gradually by drops. This diſtillation is to be continued till the retort is red-hot, and no more vapor is raiſed.

When the veſſels are cooled, they are cautiouſly to be unluted, and the liquor in the balloon is to be quickly poured into a clean and dry glaſs bottle, through a glaſs funnel; which bottle ought to be quickly ſtopped with a glaſs ſtopple. This is the method of diſtilling ſmoking ſpirit of nitre uſed by Mr. Beaumé; and it is a very good one. The ſmall earthen diſh filled with ſand, on which the bottom of the retort reſts, is very uſeful to prevent the too ſudden and too unequal application of heat, which would make it certainly liable to be broken. The fat lute of clay and linſeed oil is not capable of being injured by acids, and ſtops very cloſely. But as it remains always ſoft, it requires to be held by the linen ſoaked in lute of lime and whites of eggs.

The vapors of this ſmoking ſpirit of nitre are very elaſtic, and difficultly condenſible; for which reaſon the diſtillation muſt be ſlowly conducted, and muſt be avoided in hot weather. A brick wall muſt be interpoſed betwixt the furnace and the balloon to prevent this veſſel from being too much heated; the balloon muſt be covered with wet cloths frequently renewed, and even the ſmall hole of the balloon muſt be ſometimes unſtopped to give vent to the too rarefied and too copious vapors; otherwiſe the whole apparatus would burſt with exploſion.

When we perceive that the drops ſucceed each other rapidly, and that by unſtopping the ſmall hole, red vapors dart out the length of a foot or more with a hiſſing noiſe; this is a ſign that the veſſels are ready to burſt. The heat then muſt be leſſened, and the ſmall hole muſt be very frequently unſtopped, till the diſtillation be much moderated.

Laſtly, when we pour the nitrous acid into the bottle, we ought to be very careful not to ſtand in the way of a current of air, becauſe the vapors are very corroſive and noxious. For the ſame reaſon alſo, the mouth of the balloon ought to be ſtopped as ſoon as the liquor is poured out of it; for the fumes continue in it more than twelve hours.

DCXLIX.

DCXLIX. SPIRIT (GLAUBER's SMOKING) of NITRE. Glauber was the first chemist who thought of distilling nitrous and marine acids by means of pure vitriolic acid. By this method we may obtain a nitrous acid highly concentrated; and the process is more easy, quick, and convenient, than the preceding. This distillation ought to be made in the following manner.

Very pure nitre is to be put into a stone-ware or glass retort. Upon this nitre, one-third part of its weight of pure vitriolic acid, rectified, and highly concentrated, is to be poured through a glass funnel, the stalk of which ought to be long enough to go down into the belly of the retort, to prevent any of the acid from adhering to its neck. The apparatus of vessels is to be disposed in the same manner as in the preceding experiment, and the distillation is to be promoted with the same precautions; and with this difference only, that this distillation is sooner finished, and requires a less heat towards the end.

The spirit of nitre, distilled in these two latter methods, is the strongest and most smoking that can be obtained. This in Glauber's manner is a little less red and smoking than the other; although it may be as strong, and even more so than the other. The former is rendered so smoking by the phlogiston of the iron of the martial vitriol. Some chemists add some filings of iron in the distillation in Glauber's manner, to render the spirit more smoking.

We may observe, that spirit of nitre obtained by any of these methods is never absolutely pure. It is indeed free from a mixture of marine acid, when nitre perfectly purified has been employed; but we cannot prevent, especially in the distillation in Glauber's manner, some part of the vitriolic acid from rising with it. It must therefore be purified from this acid, when the operations or experiments require a perfectly pure nitrous acid. This purification is easily effected by adding some pure nitre to the acid, and distilling a second time; by which means the small portion of vitriolic acid mixed with the spirit of nitre is made to unite with the basis of the nitre, and is rendered so fixed that it cannot rise in distillation. We may easily perceive, that for this rectification of the nitrous acid much less heat is required than for the former distillations.

All the residuums of these distillations contain a vitriolated tartar, called *sal de duobus*.

The residuum of the distillation of spirit of nitre by clay contains a vitriolated tartar mixed with a large quantity of earth, and therefore not easily to be extracted. The clay is baked, hardened, and generally very red, because the clays employed for this purpose are ferruginous. This caput mortuum forms a very good cement used for pavements. It is used also, for sake of its color, to make compartments, and to vary the colors of sandy parterres. It is called the *cement of distillers of aqua fortis*.

The residuum of the distillation by vitriol contains vitriolated tartar, mixed with a pretty large quantity of the martial earth of this vitriol. Vitriolated tartar may be very easily obtained from it by lotion with water, which is afterwards to be filtrated, evaporated, and crystallised. A very red martial earth remains, which is called *colcothar*, or *sweet earth of vitriol*, after it has been sufficiently washed.

We may remark upon this subject, that as the nitrous acid is disengaged from its basis by the acid of vitriol, it ought naturally to be applied to the

martial earth of this vitriol. But as the nitrous acid adheres but weakly to iron, especially when this metal is calcined and deprived of its phlogiston, as it is in this operation, the heat that is employed is more than sufficient to disengage it, and to make it pass entirely in distillation.

Lastly, the residuum of the distillation of spirit of nitre in Glauber's manner, when no iron is mixed with it, forms a very white and very pure vitriolated tartar, which may be dissolved, filtrated, evaporated, and crystallised.

All these residuums generally contain also a little nitre, which not having been sufficiently in contact with vitriolic acid, has escaped its action, and is not decomposed.

DCL. SPIRIT (DULCIFIED) *of* NITRE. Dulcified spirit of nitre is a mixture of one part of nitrous acid with two parts of rectified spirit of wine, digested together. (u)

As nitrous acid acts powerfully on spirit of wine, it is rendered considerably milder by this mixture. It is used only medicinally, and is considered as aperitive, and powerfully diuretic. It is added by drops to potions and juleps, till it has given an agreeable acidity.

DCLI. SPIRITUS RECTOR. The *spiritus rector* is a very attenuated, very subtle principle, in which the smell of all odoriferous bodies peculiarly resides.

To obtain the spiritus rector from odoriferous substances, these matters are to be distilled in the cucurbit or body of an alembic placed in a water-bath, with a very gentle heat, that is, from thirty to thirty five degrees of Mr. Reaumur's thermometer, till we perceive that what rises in distillation has little or no smell.

The principle of smell in bodies is in general too subtle and too fugacious to be obtained alone and pure, by any method whatever. Accordingly it rises by means of the water contained in substances distilled in order to procure it, and is dispersed and overwhelmed in water. If the odoriferous matters from which the spiritus rector is required to be procured, were absolutely dry, and contained no other volatile principles, a little water or spirit of wine ought necessarily to be added, to furnish a kind of basis to this spirit, which would otherwise be dissipated and evaporated, so that it could not be collected.

This principle of the smell of bodies is miscible with water, with spirit of wine, and with oils. It seems however to be of different natures, according to the substances which furnish it. Its properties shew that it is in general composed of an inflammable principle, and of a saline substance, both extremely attenuated. But the spiritus rector of some substances appears to be more of a saline, and that of others more of an oily nature.

All matters, the smell of which is quick, pungent, and which do not affect the brain and nervous system, as the acrid, cruciform plants, and substances which undergo the acid fermentation, contain a spiritus rector probably more saline than oily.

Those on the contrary whose smell is sweet, nauseous, or strong, without acrimony or pungency, and which affect the head, by curing or occasioning hysterical or convulsive accidents; such are ambergrise, musk, castor, burnt

(u) The London and Edinburg Dispensatories direct that the mixture should be distilled. This operation ought to be performed with a very slow, and gradually raised fire, that explosions may be prevented.

coffee,

coffee, opium, narcotic plants, camphor, all aromatic plants, and lastly, the substances which undergo the spirituous fermentation; have, according to all appearance, a spiritus rector, which partakes of the nature of oil. For besides that the effects produced by these substances are similar to those of the vapor of charcoal, the spiritus rector of some of them is really inflammable; as, for instance, that of fraxinella, the exhalations from which form an atmosphere that may be inflamed with a lighted taper.

The spiritus rector of all aromatic plants seems particularly to be associated with their essential oils; at least, all these oils contain a good deal of it. To this principle they certainly owe their smell, and probably their volatility and thinness; for those which from age, or from not having been preserved in well closed vessels, have lost their proper smell, are at the same time much less thin and volatile, since they are no longer capable of being raised by the heat of boiling water; and besides, the plants from which the spiritus rector has been obtained, furnish little or no essential oil. *See* OILS (ESSENTIAL).

The spiritus rector, even that of aromatic plants, although it be of an oily nature, is perfectly miscible with water; which can only proceed from its great tenuity, or from the saline principle which enters its composition.

DCLII. SPIRIT *of* SALT. The spirit of salt, or acid of common salt, can only be obtained by means of a sufficiently powerful intermediate substance, to disengage it from the native fixed alkali, which is the basis of common salt. Vitriolic acid is the most proper and most useful intermediate substance for the distillation of spirit of salt. It is employed, either engaged in a basis with which it has a less affinity than with that of common salt; or pure, in order to obtain Glauber's smoking spirit of salt.

Ordinary spirit of salt is distilled by the mixture of one part of common salt with two parts of dried clay, precisely in the same manner as we have described for the distillation of spirit of nitre. *See* SPIRIT *of* NITRE. The spirit of salt obtained by this method is white and not smoking, although it may be considerably strong, if the salt and clay have been previously well dried.

We may observe, that a smoking spirit of salt cannot be obtained by means of martial vitriol, calcined till it becomes red, as is practised for the spirit of nitre. I have tried to make this distillation; and although a very violent heat was applied, but very little marine acid was procured. The true reason of this difference is, that marine acid dissolves, much more easily than nitrous acid, metallic earths deprived of their phlogiston, and adheres to them much more strongly. Hence, as soon as the marine acid is disengaged from its basis by the acid of vitriol, it applies itself to the martial earth of this vitriol, which retains it with much more strength than it is capable of retaining nitrous acid.

DCLIII. SPIRIT (GLAUBER'S SMOKING) *of* SALT. To have the strongest and most smoking spirit of salt, we are obliged to employ as an intermediate the pure vitriolic acid, as Glauber has practised. But this operation, especially when we would have spirit of salt highly concentrated, is very difficult and laborious, because the vapors are much more difficultly condensible than any others. The following is the process successfully practised by Mr. Beaumé.

Common salt is put into a tubulated stone-ware or glass retort, which is to be placed in a furnace for distilling; and to this retort a balloon is to be fitted

fitted, exactly in the same manner as for the distillation of smoking spirit of nitre. *See* Smoking Spirit *of* Nitre. This apparatus is to be left till the lute has become firm; then through the tubulated opening of the retort, by means of a glass funnel, a quantity of rectified vitriolic acid previously diluted with a little water, equal to a third part of the weight of the salt, is to be poured at several different times, and the opening is to be closed each time immediately after a part of the acid has been added.

As soon as the vitriolic acid is added, we see white vapors passing from the retort into the receiver. These are the smoking spirit of salt which this acid disengages, even without fire; for which reason these first vapors ought to be allowed to pass, before the fire be kindled; which ought not to be done till they are considerably diminished, otherwise the distillation would go on too fast at first, and the vessels might be broken.

A very little fire is to be kept up in the furnace, and only as much as is necessary to continue the distillation. Lastly, the distillation is to be conducted to the end with the same attentions which we directed for smoking spirit of nitre; and when it is finished, the spirit of salt is to be collected in the same manner.

Betwixt this process and that by which a smoking spirit of nitre is obtained in Glauber's manner, two essential differences may be perceived. The first is, that in this distillation the vitriolic acid is not added till the vessels are arranged and luted; and hence a tubulated retort is necessary. The reason of this is, that vitriolic acid disengages the acid of common salt without heat, and as soon as it touches this salt; and that the vapors which pass out copiously from the retort, by keeping the neck constantly wet, render the application of the lute impossible. When the lute happens during the distillation to be deranged, it cannot be again repaired. The shortest method then is to discontinue the operation, and begin again.

The second difference betwixt the distillation of smoking spirit of nitre and smoking spirit of salt by means of vitriolic acid, is, that water is added in the latter distillation, and not in the former. The reason of this is, that the vapors of concentrated marine acid are so much more difficultly condensible than those of nitrous acid equally concentrated, that if well concentrated vitriolic acid, and decrepitated common salt, be employed, almost all the marine acid would be dissipated in vapors which would be lost, and scarcely a sensible quantity of liquor would be obtained. *See* Acid (Marine) *for the properties of spirit of salt, and* Salt (Common).

The residuums of the distillations of spirit of salt contain Glauber's salt. In that of the distillation by means of clay, this salt is confounded with much earth, and difficultly obtainable. But the residuum of the distillation by vitriolic acid is pure Glauber's salt. This salt appears a white saline mass at the bottom of the retort. It ought to be calcined in a crucible, that any remaining acid may be expelled. It is then to be treated by solution, filtration, and crystallization.

By this distillation, Glauber first discovered the salt which he afterwards examined, and called *sal mirabile*. This name is still continued; so that it is now called *sal mirabile*, *sal mirabile Glauberi*, or *Glauber's salt*. *See* Salt *of* Glauber.

DCLIV. SPIRIT (DULCIFIED) of SALT.

Dulcified

Dulcified ſpirit of ſalt is made by mixing this acid with twice its weight of rectified ſpirit of wine, and digeſting this mixture during a month.

As this acid has much leſs diſpoſition than the vitriolic and nitrous acids to combine with inflammable matters, it cannot be ſo well dulcified as they can by ſpirit of wine.

Authors differ much concerning the methods of dulcification. The proportions are from two to five or ſix parts of ſpirit of wine to one part of ſpirit of ſalt. Some authors do not ſay whether the ſpirit of ſalt ought to be concentrated and ſmoking, or not; others require that a ſmoking ſpirit ſhould be employed. Laſtly, ſome direct the diſtillation of the mixture, and others are contented with a ſimple digeſtion. But in whatever manner the operation is performed, the acid remains crude, and not much dulcified: hence dulcified ſpirit of ſalt is not uſed in medicine; for its virtues do not eſſentially differ from thoſe of dulcified ſpirit of nitre, which is infinitely milder.

Marine acid, although very concentrated and very ſmoking, does not produce, when mixed with ſpirit of wine, but a very inconſiderable heat and effervescence, and much inferior to thoſe occaſioned by vitriolic acid, and ſtill more by nitrous acid; which difference proceeds from the little action marine acid has upon the principles of ſpirit of wine.

Theſe two ſubſtances are but little altered by being mixed together: for Mr. Pott having combined a dulcified ſpirit of ſalt with an alkali, obtained a *regenerated ſea-ſalt*, which decrepitated upon hot coals, and precipitated lead and ſilver from their ſolutions in nitrous acid into corneous metals. Nevertheleſs, we are certain that a part of the marine acid contracts an union, and even an intimate union, with ſpirit of wine: for Mr. Pott relates, that having diſtilled to dryneſs the thick matter remaining after the moſt fluid and volatile part of the mixture had been ſeparated, he found a black, reſiduous coal, which cannot be obtained by diſtilling any of theſe two matters ſeparately. *See* ETHER (MARINE).

DCLV. SPIRIT *of* SULPHUR. Spirit of ſulphur is nothing elſe than vitriolic acid obtained from ſulphur by burning.

As ſulphur cannot furniſh its acid but by burning, and as it cannot burn but in open veſſels and free air, we can therefore obtain but a ſmall quantity of acid by this method.

Before the acid of ſulphur was known to be the ſame as ordinary vitriolic acid, a ſpirit of ſulphur was prepared with great expence and trouble, upon the ſuppoſition that it had peculiar properties. For this purpoſe, ſulphur was burnt in an open crucible, placed upon a ſtand in an earthen diſh filled with hot water. A large capital or glaſs-bell was ſuſpended above this diſh. The acid of the burning ſulphur meeting the vapor of the hot water, united with this water, and fell down along the ſides of the bell, or by the beak of the capital. By this method a very weak acid was procured, which was afterwards concentrated: but at preſent this operation is only performed to ſhew, that the acid contained in ſulphur is not decompoſed during combuſtion, and that it is only one and the ſame thing with vitriolic acid.

The true method of obtaining much acid of ſulphur is to burn it in cloſe veſſels

vessels by means of a small quantity of nitre, as it seems to be practised in some places. *See* Clyssus. (x)

DCLVI. SPIRIT *of* VENUS. This name is given by chemists to the acid of vinegar highly concentrated, obtained by distilling verdegrise, or crystals of verdegrise, or of Venus, which are nothing else than combinations of copper with acetous acid.

The operation by which spirit of Venus is obtained is very easy. Nothing more is required than to put verdegrise, or crystals of verdegrise, into a retort, one third part of which ought to remain empty, as is usual: to this retort a receiver is to be adjusted, and the distillation begun with a very gentle fire: the first portions of liquor which pass are to be set apart, as they are nothing but phlegm: the distillation is to be promoted, by gradually augmenting the fire, till the retort begins to be red-hot, and nothing escapes from it.

The acid of vinegar passes in this distillation partly in white clouds, and partly in drops. This acid is very strong; because in general acids which are combined with any body whatever, are by that means deprived of all their superabundant water. Besides, as the acid of vinegar is fixed and retained in a certain degree by copper, it may be easily dephlegmated in the beginning of the distillation.

The spirit of Venus has a very vivid pungent smell, almost as suffocating as volatile sulphureous acid. The Count de Lauraguais discovered, that if this acid be heated in a wide-mouthed pan, and fire applied to it, it will burn entirely like spirit of wine, and leave no residuum. This experiment, added to the observations made by Beccher and Stahl upon the production of vinegar, shew, that spirit of wine enters as a constituent part into the composition of this acid.

(x) The greatest part of the vitriolic acid now employed is obtained by burning sulphur. The vapors of burning sulphur are the volatile, vitriolic, or sulphureous acid. These are very difficultly condensible. For which reason, very large vessels and much time are required in this operation. Some artists use leaden, and others use glass vessels. The bottom of each of these vessels is covered with a little water to assist the condensation of the vapor. Above the water is placed a small vessel capable of containing a few pounds of sulphur, to which a small portion of nitre is added by some artists, because by this addition, a larger quantity of sulphur may be burnt without access of fresh air. The vessels are to be filled with the vapor of hot water, and their sides wetted with the condensed steam: then the sulphur is to be kindled by touching it with a red-hot iron: the vapor of the burning sulphur rises slowly; and when it has risen as high as the mouth of the great vessel, this must be stopt, or very nearly stopt, that the vapor may be confined. The sulphur continues to burn till the air contained within the vessel and the nitre be no longer capable of maintaining the combustion. The vapor remains a considerable time before it be entirely condensed, notwithstanding that this condensation is facilitated by the water in the vessel, and especially by the steam of water with which the vessel was previously filled. When all the vapor of the sulphureous acid is at last condensed, the sulphur is to be again kindled, and more added if it be necessary, and the process repeated as before. When a sufficient quantity of acid is collected, it is to be taken out of the vessel; and after it has lost its *sulphureous* or volatile quality by exposure to air, it is concentrated and rectified by distillation. *See* Acid (Vitriolic), Acid (Volatile Sulphureous), *and* Concentration *of* Vitriolic Acid.

acid. The Count de Lauraguais alſo obſerved, that ſpirit of Venus well concentrated, eaſily cryſtallizes without addition; and this obſervation has been ſince confirmed by the Marquis de Courtanvaux. *See* FERMENTATION (ACID), *and* VINEGAR.

As the laſt portions of the acid of vinegar adhere pretty ſtrongly to the copper in the verdegriſe, and to the cryſtals of Venus; and as we are obliged to give a ſtrong degree of heat to expell them, they then raiſe along with them a ſmall quantity of this metal, which gives a greeniſh color to the ſpirit of Venus: but it is eaſily freed from theſe cupreous parts by a ſecond diſtillation with a very gentle heat; and then it becomes very white.

The acid of vinegar, thus concentrated, has many other properties worthy of attention; amongſt others, thoſe of forming ether when diſtilled with ſpirit of wine. *See* ETHER (ACETOUS), *and* VINEGAR (RADICAL).

We muſt obſerve, that when verdegriſe is employed for the preparation of ſpirit of Venus, we obtain very little of this ſpirit, and that it is more oily than when it is obtained from cryſtals of verdegriſe, which furniſh nearly one half of their weight of the ſpirit.

After this diſtillation, we find in the retort the copper which had been the baſis of the cryſtals of verdegriſe. This copper is divided into very ſmall parts, which, however, are agglutinated into lumps that are very friable. Its color is blackiſh, which proceeds from a covering of coal that it has received from the oily matter of the vinegar, which is decompoſed towards the end of the diſtillation. Mr. Beaumé obſerves, that this coal is eaſily kindled by the application of fire, and burns, like tinder, upon the ſurface of the copper.

This copper, not having loſt any of its phlogiſton, may be eaſily fuſed into an ingot of red copper. We ought only to add a little black flux, to prevent or repair the calcination which may be made during its fuſion.

DCLVII. SPIRIT *of* WINE. *See* SPIRIT (ARDENT).

DCLVIII. SPIRIT *of* VINEGAR. *See* VINEGAR (DISTILLED).

DCLIX. SPIRIT *of* VITRIOL. This name is given to the firſt portions of phlegmatic vitriolic acid which paſs in the diſtillation of vitriol, or in the concentration of vitriolic acid. The name is given in general to every dilute vitriolic acid.

DCLX. SPIRIT (VOLATILE) *of* SAL AMMONIAC. The volatile ſpirit of ſal ammoniac is the volatile alkali that is the baſis of ſal ammoniac, and that has been diſengaged by means of ſome intermediate ſubſtance, which alſo has taken from it ſome of its oily principle, by means of which it was capable of a ſolid or concrete ſtate; hence this ſpirit is always liquid.

The intermediate ſubſtances which have the property of producing this alteration upon volatile alkali are ſtony and metallic calxes. If two parts of quicklime ſlaked in the air, or of minium, be mixed together with one part of ſal ammoniac, and if this mixture be diſtilled, a fluor volatile alkali will be obtained in form of a very quick and penetrating ſpirit.

Mr. Schloſſer, in his Diſſertation on the Fuſible Salt of Urine, ſays, that the volatile alkali which ſerves as a baſis to the phoſphoric acid in this ſalt is always fluor, whether it be diſengaged by fire alone, or by any intermediate ſubſtance;

ſubſtance; and that concrete volatile alkali combined with this acid can never afterwards be obtained but in a fluor ſtate; which ſhews, that the phoſphoric acid has the property of taking from volatile alkali the matter by means of which it is cryſtallizable. *See for the properties of volatile ſpirit of ſal ammoniac,* Alkali (Volatile), *and* Ammoniac (Sal).

DCLXI. STEEL. Steel, conſidered chemically, is nothing elſe than iron reduced by art to a particular ſtate, which occaſions ſome changes in its properties; but theſe properties are eſſentially the ſame as thoſe of iron; that is, iron and ſteel are not two different metals, but the ſame metal in two different ſtates: therefore all the fundamental properties of ſteel are mentioned under the article Iron. We ſhall here only deſcribe the method of making ſteel, explain the theory of that operation, and mention its differences from thoſe of iron.

Stahl, Cramer, and all good chemiſts, juſtly conſider ſteel as an improved iron, which is poſſeſſed of a larger quantity of inflammable principle, ſo neceſſary to all metals, and which really contains fewer heterogeneous, and more metallic, parts than an equal bulk of iron. We ſhall be convinced of this truth by a deſcription and explanation of the methods of converting iron into ſteel, and by examining the characteriſtic properties of ſteel.

Steel may be made by fuſion or by cementation. The firſt method is uſed to convert iron into ſteel immediately from the ore. All ores of iron are not uſed indifferently for this purpoſe, becauſe ſome of theſe, which are therefore called *ores of ſteel,* are much fitter than others to furniſh good ſteel; and the ſteel extracted from them is called *natural ſteel.*

The other method of making ſteel conſiſts in chuſing the beſt forged iron, or that which is moſt malleable, whether it be hot or cold; and in impregnating this iron with a larger portion of inflammable principle, by cementation alone, without fuſion.

To underſtand well theſe methods of making ſteel, we muſt attend to two eſſential properties of iron. The firſt is, that of all metals it is the moſt difficultly fuſible; and that therefore although in the ſmelting of its ores its fuſion be much aſſiſted by the ſulphureous parts of the ore itſelf, yet, as theſe parts are always expelled as much as is poſſible, iron never enters into ſo thin and perfect a fuſion as the other metals.

The ſecond property of iron to which we ought to attend is, that the earth of this metal is capable of combining with the inflammable principle, and of being metalliſed without fuſion.

Theſe things being premiſed, it happens, in conſequence of the former property, that, in the firſt fuſion of ores of iron, we obtain only a hard and brittle iron, both from the ſulphureous parts from which this iron is not entirely diſengaged, and from the preſence of a greater or leſs quantity of earthy matters, which are either unmetallic; or which, if they be ferruginous, have not been metalliſed, from want of immediate contact with the phlogiſton of the fuel.

We may eaſily perceive that theſe earthy parts, unmetallic or not metalliſed, cannot be entirely ſeparated from the perfect iron, becauſe the fuſion is not ſufficiently thin for that purpoſe: but in proportion as the iron is deprived of ſulphur, its fuſion becomes more and more difficult, and we are obliged to have recourſe to another expedient than fuſion to diſengage it from its earthy parts,

parts, which in the firſt ſmelting remain intercepted betwixt the metallic parts. This expedient is the forge. The impure iron intended to be rendered malleable is to be heated red-hot, and ſtruck by a very heavy hammer. This percuſſion, that iron ſoftened by heat ſuſtains, preſſes ſtrongly, and ſolders or welds together the metallic parts, which only are capable of uniting together; and obliges the unmetallic parts, which are incapable of uniting with the metal, to ſeparate. By this operation theſe unmetallic parts are preſſed between the parts of the iron, and driven by degrees to the ſurface of the metal, from which they are detached in form of duſt and ſcales. This treatment, which is a kind of kneading of the iron, is to be repeated till it has acquired the proper degree of purity and ductility.

The operations by which ſteel is to be extracted from its ores are eſſentially the ſame as theſe employed for iron; but they differ from them in being much more exact; that an iron ſtill purer, more filled with phlogiſton, and better diſengaged from its earthy parts, may be obtained.

To ſucceed in this intention, much ſmaller quantities muſt be fuſed at once than when iron is to be extracted from its ore. Pieces of the firſt fuſion are to be put into crucibles filled and covered with charcoal, and expoſed to a violent heat excited by ſtrong bellows. Theſe pieces are to be well fuſed, and kept in fuſion a longer or ſhorter time, according to the nature of the ore; after which, they are to be forged, as iron is, but always in much ſmaller pieces, and till they are become perfectly ductile both when hot and when cold. Nothing then remains but to temper the ſteel, of which we ſhall preſently ſpeak.

In theſe operations, which are to be ſeveral times repeated, the iron that is changed into ſteel muſt evidently be much better purified, and furniſhed with a much greater quantity of inflammable principle, than in the ſmeltings and fuſions of large quantities of iron. As the maſſes of metal are ſmall in theſe operations for the procuring of ſteel, and as they are ſurrounded with a much larger proportion of charcoal, the fuſion is not only more compleat, by which the ſeparation of the earthy unmetallic parts is much promoted, but alſo a greater number of ferruginous parts are well metalliſed; and as all theſe parts of iron are in more intimate contact with the charcoal, which is capable of ſupplying them with inflammable principle, they receive the whole quantity of this principle, with which they can unite.

The ſame obſervation may be applied to the operation of the forge practiſed upon ſmaller maſſes; for the heterogeneous parts are much more eaſily and copiouſly preſſed out of ſmall maſſes than great.

This exact purification of iron, by which it is converted into ſteel, muſt evidently be attended with conſiderable loſs, or diminution, from the ſeparation of all its heterogeneous parts. This diminution amounts to nearly one half of the weight of the iron. This great loſs does not proceed altogether from the ſeparation of heterogeneous parts; for in all the operations uſed for this ſeparation, ſome part of the metal is always deſtroyed and burnt, although all poſſible precautions are taken to diminiſh this inconvenience, by ſecuring the melted or red-hot metal from the contact of external air as much as is poſſible.

Artificial ſteel is made without fuſion from iron ready forged. The chief point to be attended to in the making of the beſt artificial ſteel, is to chuſe the iron which is moſt perfect and moſt malleable, either when it is hot or cold; which quality always ſhews that the iron is well purified. It is firſt to be forged into plates or bars, rather ſmall than large, according to the works for which it is intended; and it is then to be cemented with matters capable of giving to it much inflammable principle. The matters which compoſe this cement vary according to the uſes of different manufactures. They are all good, provided they contain no ſulphur, or vitriolic acid, which might form ſulphur during the operation; becauſe ſulphur, having much affinity with iron, would certainly unite with this metal, would entirely or partly fuſe it, and would, by reducing it to a mineral or pyritous ſtate, give to it qualities very different from thoſe which good ſteel ought to have.

The matters which enter into the compoſition of the cement for ſteel, are the coals of animal or vegetable ſubſtances mixed with aſhes, calcined bones, and other matters of this kind. Mr. Cramer propoſes the two following receipts of cements for ſteel, which appear to be very good.

Take one part of powder of charcoal, half a part of wood-aſhes, and mix them very well together: or,

Take two parts of charcoal, moderately pulveriſed; one part of bones, horns, hair or ſkins of animals, burnt in cloſe veſſels to blackneſs, and powdered; half a part of wood aſhes, and mix them well together.

When ſteel is to be made, the bars of iron are to be placed vertically in a cylindrical crucible, which ought to be three inches higher than the bars, and into which a ſtratum of the cement of about the thickneſs of a finger has been previouſly put and preſſed down. The bars ought to be about an inch diſtant from each other, and from the ſides of the crucible. The interſtices and crucible are then to be filled with cement, ſo that the bars ſhall be covered with about the thickneſs of two inches at leaſt. The crucible, previouſly covered with a lid which fits it exactly, and which muſt be carefully luted with clay mixed with ſand, is to be placed in a furnace where an equal fire is to be kept; ſo that the crucible ſhall be red-hot during eight or ten hours: the iron will then be found to be converted into ſteel, which will be ſo much better as the iron employed was of a better quality: it then only requires to be tempered. We may obſerve, that in this operation the iron ſuffers no diminution of weight, and no ſcoria appears upon its ſurface, as Mr. Cramer remarks. By the ſole addition, therefore, of a new quantity of phlogiſton, the iron acquires the quality of ſteel. Thus, if this iron contained ſome parts of martial earth which was not metalliſed, by the cementation they are metalliſed, and the iron or ſteel are thereby improved: but if the iron contained ſome earthy unmetallic parts, they are not ſeparated by this operation, becauſe the metal has not been fuſed; and as the beſt forged iron which is uſually ſold is never ſo well purified from theſe extraneous matters, as that which is converted into ſteel in the great works for procuring ſteel from the ore of iron; hence, in general, artificial ſteel made by cementation is not ſo perfect as that made by fuſion.

We may obſerve that, in the cementation above deſcribed, the iron combines with a part of the phlogiſton of the cement, without fuſion; which effect proceeds from a peculiar property of the earth of iron by which it is capable of

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combining with the inflammable principle, and of being metallised without fusion, which is, neverthelefs, neceffary for the reduction of all other metallic earths.

The fteel which has received only the above-mentioned preparations differs from iron in its color, which is more dark and brown; in its grain, which is finer and clofer; in poffeffing a greater ductility, flexibility, and foftnefs: but the great difference of fteel from iron, which renders it more valuable for many purpofes and arts, is the extreme hardnefs it acquires by being tempered.

This operation is very fimple. It confifts in making fteel red-hot, and then in plunging it fuddenly in cold water. In an inftant all the qualities of this fteel are changed by this tempering; fo that from being very ductile and foft, it becomes fo hard and fo ftiff, that it is no longer capable of being cut by the file, but is itfelf capable of cutting or piercing very hard bodies; that it does not yeld to the hammer, but may be fooner broken in pieces like a flint, than be extended. It is fonorous, brittle, very elaftic, and capable of acquiring the moft lively and moft beautiful polifh, as we fee in finely wrought toys of fteel.

The ufe of this metal is very extenfive for numberlefs convenient and neceffary utenfils of all forts, of which without it we fhould abfolutely be deprived: but what renders its ufe ftill more general is, that we can diverfify at pleafure its hardnefs and ductility, by varying the temper. The hotter the fteel is when tempered, and the colder the water into which it is plunged, the greater hardnefs it acquires; but, at the fame time, it becomes fo much more brittle. This very hard temper is neceffary for certain tools defigned to cut very hard bodies. On the contrary, the lefs hot the fteel is when tempered, and the hotter the water is in which it is tempered, the lefs hard it becomes, and alfo the greater ductility it retains; and hence many tools may be made of it fit for cutting bodies moderately hard, which tools are lefs liable to have their points broken, or their edges notched, than if they were made of a harder fteel.

No other general rule can be given for the tempering of fteel than that we have mentioned. The proper degree of heat is always relative to the ufe to which the tools to be made of this fteel are to be applied.

Another very convenient property of fteel is, that after it has been tempered, it may be again untempered and foftened to any degree that we think proper. For which purpofe we have only to heat it more or lefs, and to let it cool flowly. By this method we may foften the hardeft-tempered fteel.

As the temper is a very effential point with regard to fteel, and that the beft is in general that which gives the greateft hardnefs, and deftroys the leaft of the ductility of the metal, various fubftances are ufed, into which fteel to be tempered is plunged. Such are fuet, oil, urine, water impregnated with foot, with fal ammoniac, or with other falts. Thefe particular methods are the bafes of many fecrets in different manufactures; their advantages cannot be afcertained without a very accurate and continued examination. Very interefting refearches remain to be made on this fubject.

Steel is ufually fold tempered, becaufe, in many manufactures of it, the cuftom is to temper it as foon as it is made, probably that the purchafers of it may be better able to judge of its quality. When this fteel is to be ufed, it

must be untempered, that it may be extended, filed, and receive the form intended to be given to it; after which each workman tempers it again in his manner. But we also find amongst merchants English steel in small bars, which is not tempered, and which is very good.

Well polished plates of steel, put on a gentle fire of charcoal, acquire different colors on their surface, and pass successively through several shades, as they become hotter, in the following order, white, yellow, orange, purple, violet, and lastly, blue, which disappears and leaves a water-color, if the steel has been heated too much or too long. These different shades mark the degree of heat or of annealing applied to different tools or utensils. The most generally used shade is the blue, such as that given to steel springs.

One of the most important properties of steel is the magnetic quality which it is capable of acquiring much better than iron. Good mariners compasses cannot be made without needles of steel.

From what we have said, we may judge that steel is much better purified iron than any other iron, impregnated with a larger quantity of inflammable principle, and hardened by the temper. Some celebrated natural philosophers, but who were not chemists, have advanced, that steel was only iron which still retained something of its mineral nature, and that its state was intermediate betwixt that of cast iron and soft forged iron. But this opinion is manifestly erroneous. They have been deceived by the hardness and brittleness of cast iron, which are nearly as great as in steel. But these qualities proceed from a remaining part of the mineralising substances, which leave it a pyritous character, very different from that of true steel, since this can only be hardened by the temper, and since in the preparation of it all sulphureous matter must be carefully avoided. The mistake of these authors proceeded from their ignorance of the inflammable principle, the properties of which have been so well explained by the illustrious Stahl, and from their being led into an error by the old chemists, who perpetually confounded phlogiston, or the purest and simplest inflammable principle of all bodies, with sulphur, with sulphureous matters, and with most other inflammable compounds.

Steel may be un-made, or reduced to the state of iron, by a management similar to that by which it is made, that is, by cementation. But the cement used for this purpose must be composed of substances entirely free from inflammable matter, and rather capable of absorbing it, as calcareous earth and quicklime are. By a cementation then with these matters continued during eight or ten hours, steel is reduced to the state of iron.

Stahl considers it as an undecided question, whether steel be more fusible than iron, and says, that the workmen cannot decide it from the violence of fire necessary to melt either of them. He believed with reason, that this question might be decided by melting these metals in the focus of a burning speculum. Mr. Macquer says, that by this method he found steel much more fusible than iron (y). This greater fusibility of steel can be only attributed to

(y) Soft forged iron can scarcely without addition be brought into perfect fusion by the heat of our furnaces, till the phlogiston of the fuel has converted it into steel. But steel is daily melted and cast into ingots, called *cast-steel*, by which it is rendered more uniform and similar in all its parts, and thereby fitter for being wrought into the finer kinds of utensils for which steel is employed. This cast-steel, when again reduced

the greater quantity of phlogiſton united with it, as phlogiſton is in general the cauſe of the fuſibility of metals. (z)

duced to the ſtate of forged iron by cementation with abſorbent earths, is the moſt uniform, equal, perfect iron which can be obtained.

(z) By converſion of iron into ſteel, this metal acquires a cloſer, more compact and finer-grained texture, greater hardneſs, elaſticity, tenacity, ſonorouſneſs, and diſpoſition to receive the magnetic property; and, as is ſaid, a greater gravity, both abſolute and relative. It is alſo rendered leſs liable to ruſt by expoſure to air; and leſs liable to emit ſparkles when heated. The colors or iriſes which ſteel acquires by expoſure to heat, and which are marks by which workmen know when any required heat is given, are not peculiar to ſteel and iron, but may alſo be produced by the ſame means on all other calcinable metals. Theſe colors proceed from a calcination gradually advancing on that part of the metals which is expoſed to air. And as the particles of metals in their different degrees of calcination are probably of different ſizes, ſo they muſt acquire (according to Sir Iſaac Newton's theory, which ſhews that the colors of bodies depend on the ſize of their integrant parts) different reflective powers, and exhibit changes of colors.

Steel may be made by fuſion, or by cementation with inflammable matters. Anciently ſteel is ſaid to have been made by immerſing forged iron during ſome time in melted crude iron. Forged iron may alſo be changed into ſteel, as Wallerius affirms, by immerſion in melted ſcoria; or by fuſion with black flux, glaſs-gall, or borax; or by ſtrewing ſea-ſalt upon heated iron, and extinguiſhing it in dung.

Various opinions are formed concerning the cauſe of the difference between iron and ſteel. The moſt general opinion attributes this difference to the preſence of a larger quantity of phlogiſton in the latter than in the former. Some authors, attending chiefly to the method of converſion by fuſion, conſider that operation only as a purification of the iron from earthy and heterogeneous particles, and ſteel merely as a more pure and perfect iron. Others, obſerving ſome ſimilitude in the texture of ſteel to certain kinds of caſt iron, and the hardneſs of both theſe, without attending to their eſſential differences, have imagined that the ſtate of ſteel was intermediate betwixt that of caſt and that of forged iron. Laſtly, ſome metallurgiſts maintain that the converſion of iron into ſteel is effected not by abſorption of phlogiſton, but by expulſion of ſulphureous or acid particles. To ſupport this opinion, they obſerve, 1. That ſteel is leſs diſpoſed than iron to ruſt; the cauſe of ruſt being, as they think, an acid contained in iron; 2. That ſteel emits fewer ſparkles under the hammer than iron, which ſparkles are found to be moſt frequent in iron abounding with ſulphur, as in red-ſhort iron; 3. That iron may be converted into ſteel by cementation with alkaline ſalts, capable of attracting the acid and ſulphur; 4. That in the preparation of ſteel by fuſion, the metal is rather expoſed to a diſſipation of its inflammable parts and burnt, than further phlogiſticated; and that this operation is accordingly called by workmen *the burning of ſteel*.

In the preparation of ſteel by fuſion, probably much of the earthy matters contained in the iron may be ſeparated, and any contained acid or ſulphur may be burnt or diſſipated. But the converſion of ſteel into iron by cementation with abſorbent earths, in which operation no acid or ſulphur can be abſorbed by the metal, ſhews that the difference between iron and ſteel does not conſiſt in the preſence of an acid or of ſulphur in the iron, but in the preſence of ſome ſubſtance in the ſteel, which the inflammable cementing ſubſtances can give to it, and of which abſorbent earths can deprive it. This ſubſtance has been, with great probability at leaſt, believed to be phlogiſton; by the addition of which the metal acquires a new texture, together with the hardneſs, elaſticity, and other peculiar properties of ſteel: we doubt not, however, that in the operations for making ſteel, by fuſion or by cementation, any contained acid or ſulphur may be expelled, and thus the metal may be meliorated, and rendered leſs liable to ruſt and to emit ſparkles.

The

The affinities and medicinal virtues of steel are the same as those of iron. *See* Iron.

DCLXII. STONES. This name is given in general, both in chemistry and in natural history, to many bodies of very different natures. But generally hard and compact bodies of an earthy nature are called *stones*.

As many different kinds of stones as of earths may be distinguished. For the parts of every kind of earth being united and agglutinated together, are capable of forming, and actually do form stoney bodies. But as this union of the integrant parts of any earth does not really change the nature of this earth; and as it always has the same essential properties, especially when considered chemically; we refer to the word Earth for all that we have to say concerning stones. The origin, and the sensible qualities by which naturalists distinguish different kinds of stones, are treated of in *Mr. Bomare's Dictionary of Natural History*.

Several chemical preparations are also called stones, of which we shall here treat.

DCLXIII. STONE (CAUSTIC), *or* Common Caustic. *See* Caustic.

DCLXIV. STONE *of* BOLOGNIA. This stone has been much celebrated for the property it has of becoming phosphoric by calcination. It is a heavy selenitic spar. All spars of that kind, and also several other stones, have the same property. *See* Phosphoric (Stones), *and* Spars.

DCLXV. STONE (INFERNAL), *or* Lunar Caustic. *See* Caustic (Lunar).

DCLXVI. STONE (PHILOSOPHER'S). This name is given by alchemists to the preparation, by which metals may be transmuted, gold and silver made, and all the wonders produced of (what they call) the *great work*. *See the articles* Metals *and* Metallisation.

DCLXVII. SUBLIMATION. Sublimation is an operation by which volatile and solid substances are collected and obtained.

This operation is founded on the same principles as distillation, and its rules are the same, as it is nothing but a dry distillation. Therefore all we have said on the article Distillation is applicable here, especially in those cases where sublimation is employed to separate volatile substances from others which are fixed or less volatile.

Sublimation is also used in other cases; for instance, to combine two volatile matters; as in the operation of the sublimates of mercury; or to collect some volatile substances; as *sedative salt*, *sulphur*, and all the preparations called *flowers*.

The apparatus for sublimation is very simple. A matrass or small alembic is generally sufficient for the sublimation of small quantities of matter. But the vessels and the method of managing the fire vary according to the nature of the matters which ought to be sublimed, and according to the form which ought to be given to the sublimate.

The beauty of some sublimates consists in their being composed of very fine, light parts; such as almost all those called flowers; as *flowers of sulphur*, and of *benjamin*,

benjamin, *sedative salt*, and others of this kind. When the matters to be sublimed are at the same time volatile, a high cucurbit, to which is adapted a capital, and even several capitals placed one upon another, are to be employed. The sublimation is performed in a sand bath, with only the precise degree of heat requisite to raise the substance which is to be sublimed; and the capitals are to be guarded as much as is possible from heat. The height of the cucurbit and of the capitals is well contrived to accomplish this intention.

When along with the dry matter which is to be collected in these sublimations a certain quantity of some liquor is raised, as happens in the sublimation of sedative salt, and in the rectification of volatile concrete alkalis, which is a kind of sublimation, a passage and a receiver for these liquors must be provided. This is conveniently done by using the ordinary capital of the alembic, furnished with a beak, and a receiver.

Some sublimates are required to be in as solid and compact masses as their natures allow. Of this number are camphor, sal ammoniac, and all the sublimates of mercury. The properest vessels for these sublimations are bottles or matrasses, which are to be sunk more or less deeply in sand, according to the volatility and gravity of the matters that are to be sublimed. In this manner of subliming, the substances having quitted the bottom of the vessel, adhere to its upper part; and as this part is low and near the fire, they there suffer a degree of heat sufficient to give them a kind of fusion. The art therefore of conducting these sublimations consists in applying such a degree of heat, or in so disposing the sand, (that is, making it cover more or less of the matrass) that the heat in the upper part of the matrass shall be sufficient to make the sublimate adhere to the glass, and to give it such a degree of fusion as is necessary to render it compact; but at the same time, this heat must not be so great as to force the sublimate through the neck of the matrass, and dissipate it. These conditions are not easily attained, especially in great works.

Many substances may be reduced into flowers and sublimed, but which require for this purpose a very great heat with the access of free air, and even the contact of coals, and therefore cannot be sublimed in close vessels. Such are most soots or flowers of metals, and even some saline substances. When these sublimates are required, the matters from which they are to be separated must be placed among burning coals in open air, and the flowers are collected in the chimney of the furnace in which the operation is performed. This process is called *sublimation in the manner of Geber*. The *tutty*, *calamine*, or *pompholix*, which are gathered in the tops of furnaces in which ores are smelted, are sublimates of this kind.

DCLXVIII. SUBLIMATE (CORROSIVE). This preparation, called also *mercury corrosive sublimate*, is a mercurial salt, in which mercury is united with the largest quantity of marine acid with which it is capable of combining intimately.

This salt is called *sublimate*, because it can only be well prepared by sublimation; and it is called *corrosive*, because it is one of the most corrosive salts or even the most corrosive of all salts with metallic bases.

Corrosive sublimate may be made by several processes, which, however, are all so contrived, that the vapors of mercury and of marine acid shall meet in the same subliming vessel.

The

The most usual method consists in mixing well nitrous mercurial salt with vitriol of iron and common salt, all well dried; and in promoting the sublimation, as we have said under the article MERCURY.

Another process consists in dissolving mercury in concentrated vitriolic acid, as when turbith mineral is made; in triturating the white saline mass remaining after this solution, previously dried, with an equal weight of dried sea-salt; and in subliming this mixture in a matrass with the heat of a sand-bath, by encreasing the fire till nothing more is sublimed. This process is given by Mr. Boulduc, in the Memoirs of the Academy for the Year 1730. Mr. Spielman observes, in his *Chemical Institutions*, that Kunckel had given it formerly, in a work called *The Chemical Laboratory*.

In this operation, the acid of the vitriolic mercurial salt quits the mercury to unite with the alkali of common salt, to which it has a greater affinity, and with which it forms a Glauber's salt, that remains at the bottom of the matrass after the sublimation; while the marine acid on one side, and the mercury on the other, being both disengaged, are reduced into vapors by the effect of heat, unite strictly together, and form the corrosive sublimate, which attaches itself to the upper part of the matrass. This sublimate consists partly of a white, semi-transparent, saline mass, and partly of shining crystals, composed of small and pointed plates.

This method of making corrosive sublimate is well-contrived, and seems preferable to the ordinary process; 1. Because the mercury, being previously dissolved by vitriolic acid, is as easily and perfectly mixed with common salt in this as in the ordinary process. 2. Because the acid of the vitriolic mercurial salt disengages powerfully and plentifully the acid of common salt; and that it is necessary, as we shall see, that the mercury should meet all the quantity of marine acid with which it is capable of uniting, to obtain the most corrosive sublimate. 3. The process of Kunckel and Mr. Boulduc is more simple than that with vitriol; the operator is less exposed to the acid vapors, the mixture from which the sublimate is separated is less voluminous, and therefore this method is justly preferred.

We think we ought to observe, upon the subject of this process, that almost all chemists, who have mentioned it since Mr. Boulduc, say, that it is made from a mixture of turbith mineral with common salt. This is an inaccuracy capable of leading readers into a mistake; for the vitriolic mercurial salt, employed by Mr. Boulduc, is very different from *turbith mineral*; it contains a large quantity of concentrated, vitriolic acid, which is very necessary in the operation; whereas turbith mineral contains very little or no vitriolic acid, when it has been well washed, according to Mr. Beaumé's experiments; and consequently if turbith mineral be employed with common salt, in the proportions directed by Mr. Boulduc, we should obtain no sublimate, or but a very small quantity of a sublimate, which would not be corrosive.

The saline sublimates of mercury may be obtained by several other processes; for instance, the vitriol of the ordinary mixture may be omitted; we might also employ crude mercury instead of the mercurial nitre, and triturate it a long time with vitriol and salt, as Lemery says, or sublime the *white precipitate* alone. But we shall say no more of these methods, because they are all inferior to those we have mentioned, when a very corrosive sublimate is required; altho' some

ſome of them, as the ſublimation of white precipitate, be very convenient, and may furniſh a ſublimate which probably is very good, when it is intended to be afterwards converted into *ſweet mercury*, or *mercurial panacea*. But we muſt mention another method of making this ſaline ſublimate of mercury, propoſed alſo by Lemery, becauſe it is founded on a miſtake which ought to be made known.

This method conſiſts in triturating crude mercury with twice its weight of common ſalt; and in ſubliming this mixture, from which, according to Lemery, may be obtained a white ſublimate, leſs corroſive indeed, as he acknowledges, than the ordinary ſublimate, but which, nevertheleſs, is corroſive.

What Lemery ſays upon this ſubject is certainly true; but a modern author infers from thence, that mercury decompoſes common ſalt, that marine alkali has not a ſtronger affinity than mercury with marine acid, and that this experiment contradicts eſtabliſhed affinities. But none of all theſe conſequences is juſtly deducible. We explain this kind of paradox in the following manner.

For this purpoſe we muſt previouſly know, 1. That common ſalt, even when cryſtallized very regularly, is not a pure, homogeneous ſalt; but that it is intimately mixed with another ſalt, compoſed of marine acid, neutralized by a calcareous earth. 2. That the acid of this marine ſalt, with calcareous baſis, eſcapes merely by the action of fire, and without any other intermediate ſubſtance than a little moiſture. 3. That when mercury is ſublimed with ordinary common ſalt, that is, common ſalt which has not been purified from the mixture of this ſalt with calcareous baſis, it combines with the acid of this latter ſalt, and not with that of the true common ſalt, and forms a mercurial ſublimate. The proof of this is, that if, as Mr Beaumé has done, common ſalt be diſſolved in water, and if into this ſolution ſome of the lixivium of ſoda be poured, till no more earth be precipitated, in which operation the ſalt with earthy baſis is evidently decompoſed, and is changed into a ſalt with baſis of fixed alkali; and if the pure ſalt remaining in the liquor be afterwards cryſtallized, and mixed with mercury, and the ſublimation be attempted, not a particle of ſaline ſublimate of mercury will be obtained. This experiment has been verified moſt ſcrupulouſly by Mr. Beaumé. Mercury ſingly cannot decompoſe common ſalt, therefore none of the conſequences inferred from the inaccurate experiment of Lemery are juſtly deducible. We might draw other conſequences not very favourable to the chemiſt alluded to, but we abſtain from them on account of his perſonal merit, and that we may not imitate the harſh and ſatyrical criticiſms which diſhonour his writings.

The ſublimates compoſed of mercury and marine acid, in which the metallic ſubſtance has had an opportunity of combining with all the acid with which it was capable of uniting, are evidently combinations of a preciſe and determinate proportion of theſe two ſubſtances. Accordingly corroſive ſublimate, when well made, that is, as corroſive as it can be, being ſublimed a ſecond time with new marine acid, does not unite with a larger quantity of acid, nor become more corroſive. But we do not yet ſeem to have determined preciſely the proportion of marine acid, relatively to that of mercury, in the moſt corroſive ſublimate. According to Lemery, ſixteen ounces of mercury produce nineteen ounces of corroſive ſublimate; and, according to Takenius, in the great works in Holland, where this preparation is made, 280 pounds of crude mercury furniſh 360

pounds of sublimate; which would seem to prove, that the quantity of marine acid is greater in the sublimate mentioned by Takenius than in that by Lemery. But as more of the mercury may be dissipated when the quantity operated upon is but small, than when it is large, we can ascertain nothing from comparing together the results of these two authors. However, we see that the quantity of mercury is much larger than that of the acid, since even in the sublimate of Takenius, the quantity of mercury was more than three times the quantity of acid; which deserves to be remarked, as we shall see when we mention the principal properties of corrosive sublimate.

The specific gravity of this mercurial salt has not been hitherto determined, but it is evidently very considerable. It is very crystallizable, either by the usual method for crystallizing salts, or by sublimation, and the form of its crystals is the same in both cases. It is not deliquescent, is difficultly wetted by water, and, in this respect, is similar to arsenic. It is one of the salts which are very little soluble in water. According to the experiments of Mr. Spielman, an ounce of distilled water can dissolve only thirty grains of it, with the assistance of a heat of fifty degrees of Fahrenheit's thermometer, which corresponds nearly to the tenth degree above the freezing point of Mr. Reaumur's thermometer; that is, that with this heat water can dissolve only a nineteenth part of its weight of corrosive sublimate.

All these properties of corrosive sublimate are naturally deducible from the large quantity of mercury which enters its composition; it perfectly resembles in this respect all the neutral salts, which contain a matter that is not saline, intimately joined to the saline principle. But this circumstance is very remarkable, that corrosive sublimate has at the same time very contrary properties, by which it also resembles those neutral salts in which the acid is but little connected and imperfectly saturated with their basis. These properties are, 1. Its corrosive quality, which renders it one of the most violent and active poisons; and, 2. Its capacity of receiving a much larger proportion of mercury, which unites intimately with its acid, saturates it entirely, and even so completely, that this salt, from being very corrosive, is rendered, by this new addition of mercury, a sweet sublimate, almost insipid, almost unsoluble in water, and which has nothing in common with a neutral salt but external appearance.

These latter properties of corrosive sublimate do not allow us to doubt that marine acid, although already united in this salt with a large quantity of mercury, and even very intimately, is yet very far from being saturated. Accordingly this acid is, at the same time, in two states in some measure contrary. Several of the properties of corrosive sublimate seem to shew that its acid is saturated as compleatly as the acid of the most perfect neutral salts; while other properties indicate that it is far from being compleatly saturated.

To form a just idea of this singular state of marine acid in corrosive sublimate, we must first of all observe, that we should judge very erroneously of the state of the acid of a neutral salt, if we considered the properties of this salt as depending only on its acid. We have elsewhere observed, and we shall prove it further in this article, that bodies which are not saline, being united to acids in neutral salts, have their peculiar action as well as these acids; and that the properties of these salts are always the result of the combined properties of their acids and of their bases.

In

In the ſecond place, we ought to recollect the diſtinction we have made under the article Saturation, into *relative ſaturation*, and *abſolute ſaturation*, which are two things very different; becauſe, in fact, it happens in many combinations, that a principle is in a relative, perfect ſaturation, with regard to another; that is, that it is united with all the quantity of this ſecond principle which it can diſſolve, although it be very far from being in a ſtate of abſolute ſaturation; that is, from having ſo exhauſted all its action upon this ſecond principle, that no more remains to be exerciſed upon any other ſubſtance: For, if this were not ſo, we could not make any decompoſition by an intermediate ſubſtance. Thus in bodies compounded of two principles, ſuch as, for inſtance, neutral ſalts, one of their principles, and not the other, may be relatively ſaturated. Alſo one of the two principles, or both, may be in a perfect, relative ſaturation, although one or both be far from abſolute ſaturation.

Theſe things being premiſed, if we reflect on the properties of corroſive ſublimate, we ſhall eaſily perceive, 1. That the marine acid cannot be united with ſo large a quantity of mercury as it is in this ſalt, without being conſiderably approximated to a ſtate of abſolute ſaturation; hence corroſive ſublimate does not redden blue colors, has no acid taſte, does not attract the moiſture of the air, is very cryſtallizable, and not very ſoluble in water; in a word, that it is nearly in the ſame ſtate as ſeveral neutral ſalts, as vitriolated tartar and others, the acids of which are generally conſidered as being well ſaturated.

Secondly, We ſhall eaſily diſcover alſo, that although the acid of corroſive ſublimate approaches as much to abſolute ſaturation as the above-mentioned properties indicate, it is not nearly in a ſtate of relative ſaturation with regard to the mercury; ſince we know that it is capable of uniting again with a much larger quantity of mercury than is in corroſive ſublimate, as is ſhewn by the transformation of corroſive ſublimate into ſweet mercury; and we ſhall naturally conclude from theſe facts, that marine acid is capable of uniting with ſo large a quantity of mercury, that it cannot be entirely ſaturated with that ſubſtance, without exhauſting almoſt all the action it is capable of, and approaching nearly to the ſtate of abſolute ſaturation. Accordingly we ſee, that the properties of this acid become inſenſible, and are almoſt annihilated in ſweet mercury.

Thirdly, in reaſoning ſtill from principles above-mentioned, and in applying them to corroſive ſublimate, it will evidently appear, that although the acid of this ſalt is not nearly ſaturated with mercury, as we have obſerved, the mercury is nevertheleſs in a ſtate of relative ſaturation, with regard to the acid; ſince, according to Mr. Rouelle's experiment, this ſalt cannot by any means receive a larger quantity of acid. But if, on the other ſide, we attend to the quantity of mercury in corroſive ſublimate, it will appear very probable, that although this mercury be ſaturated with acid as much as it can be, and that in this reſpect it be in a ſtate of perfect relative ſaturation, yet it is very far from having exhauſted upon this acid all the tendency it has to combination in general, and from being in a ſtate of perfect, abſolute ſaturation. In fact, on one ſide, the aggregation of the mercury is broken in corroſive ſublimate, and conſequently all its integrant parts are capable of exerting their general tendency to combination: but, on the other ſide, theſe parts of mercury are united but to a very ſmall quantity of acid, and probably much of their tendency to union remains

therefore unsatisfied; and we may reasonably conjecture, that from this condition, or state of the mercury in corrosive sublimate, proceeds the causticity of that saline matter.

This notion will undoubtedly appear very bold to those who are accustomed to consider the causticity of saline matters as an effect only of the concentration and imperfect saturation of their saline principles.

But we repeat it, that we should judge very erroneously of the properties of any compound body, if we were to attribute them to one of its principles only. On the contrary, all the phenomena of chemistry shew, that all the constituent parts of any compound contribute more or less to all the properties of this compound. All the parts of matter are active, by the general tendency which they have to mutual combination. Nothing is purely passive in nature; and if certain substances seem to us to be inactive and inert, it is because their parts, having exhausted all their tendency and activity one upon another, by their union, are in a seeming rest, which we call saturation, and do really become inactive with regard to many other bodies: but when by some cause this union is broken, and its parts become disengaged, their essential activity then appears again in all its force, they resume all their tendency to combination, they are in a violent state, till they find some substance with which they may unite, and satisfy this tendency. This violent state, this *nisus*, are the same thing as causticity, or rather this latter quality is an effect of the former qualities rendered sensible by their exertion upon animated bodies. Accordingly, all matter in nature, however inactive and passive it may seem, is capable of becoming, by the separation of its primary integrant molecules, an agent or solvent, and a very powerful corrosive.

We conceive then, that in corrosive sublimate the aggregation of the mercury being broken, its primary integrant molecules are, on one side, in this violent state, in this tendency to union above-mentioned; and, on the other side, that as this tendency to union is only capable of being satisfied partly, and imperfectly, by the marine acid, much of it remains unsatisfied, which gives a proportionable degree of causticity to these molecules; so that the mercury itself of the corrosive sublimate is corrosive, and probably much more so than even the marine acid.

However strange and singular this opinion may appear, we shall find, by reflecting on the nature of corrosive sublimate, that no other cause of its causticity can be conceived. In fact, we must allow that this salt is much more caustic than pure marine acid. For we are certain that a gros [72 grains] of this acid, or more, diluted in water, might be swallowed without the least inconvenience; whereas half the quantity of corrosive sublimate, diluted in the same or a much larger quantity of water, would infallibly poison. If then we suppose that the causticity of this salt is nothing else than the causticity of the marine acid contained in it, how can we conceive that this acid, which, very far from being disengaged, and from possessing all its acidity in corrosive sublimate, is, on the contrary, united with more than thrice its weight of mercury, and is neutralised so as to form a very crystallizable salt, not deliquescent, and not very soluble in water, which does not change to red the blue colors of vegetables, and gives no mark of acidity, can be infinitely more corrosive than the same acid when free and disengaged? We might as well say, that vitriolic acid is more

more corrosive in vitriolated tartar than when pure. The causticity then of corrosive sublimate must be chiefly attributed to the mercury, which is the predominant and least saturated part of that saline substance. The mercury in corrosive sublimate appears to be nearly in a similar state as the earthy principle in fixed alkalis; that is to say, its aggregation is destroyed at least in great measure, and its quantity is very large in proportion to that of the saline principle. Accordingly, corrosive sublimate, instead of changing the blue colors of vegetables to red, as acids do, changes them to green, as if it were an alkali, according to the observations of Mr Rouelle; and in the same manner as alkalis seem to owe their causticity to the proportion and peculiar state of their earth, so also does the causticity of corrosive sublimate proceed from the quantity and disposition of its mercury. This causticity then is rather of an alkaline than of an acid kind.

An objection might be made here, that if the causticity of corrosive sublimate depended on the mercury, it ought to be encreased by encreasing the proportion of the mercury; whereas we know, that the addition of more mercury has a contrary effect, as we find from the instance of sweet mercury.

The answer to this objection is not difficult. Although the causticity of corrosive sublimate depends more on its mercury than on its acid, we cannot doubt that this acid also contributes to produce this effect, according to the general rule, that all the principles of bodies conduce more or less to their properties: but the acid of sublimate is indeed nearly in the state of absolute saturation, although it is not quite in that state; and however neutralised it may seem, it is yet capable of a certain degree of action: but when it is totally saturated with mercury, it is then also completely in a state of absolute saturation; because this acid is capable of uniting with so much mercury, that when it is combined with this metallic substance, its relative saturation and its absolute saturation are almost the same thing. We need not then be surprized, that in this respect the causticity of the sublimate is considerably diminished; but, besides, when the quantity of mercury much exceeds what ought to be contained in corrosive sublimate, we may easily perceive that the parts of the mercury, being pressed nearer the parts of the acid, are also more and more united together, and approach more nearly to the state of aggregation; in which state mercury cannot have any causticity. *See for the properties, chemical and medicinal, of corrosive sublimate, the articles* ACID (MARINE), *and* MERCURY.

DCLXIX. SUBLIMATE (SWEET). *See* MERCURY (SWEET).

DCLXX. SUBLIMATE (RED). If a solution of mercury in nitrous acid be evaporated and dried, and then exposed to a strong heat in a matrass, the nitrous acid will be separated from the mercury in great measure, and will be dissipated in red vapors; the saline mass remaining in the matrass acquires at first a yellow color, which afterwards changes to an orange color, and lastly to a red. This is called *red precipitate*. But by exposing this red matter to greater heat, it is sublimed, while its color is preserved. It is then called *red sublimate*. This sublimate is not used.

DCLXXI. SUGAR. Sugar is a crystallizable essential salt, of a sweet agreeable taste, contained, more or less plentifully, in many kinds of vegetables;

vegetables; but in moſt of them in ſo ſmall a quantity, or confounded with ſo much extraneous matter, that it cannot be obtained from them with profit.

The plant which contains and furniſhes moſt of this eſſential ſalt is a kind of reed, which grows in hot climates, called *ſugar-cane.*

The method uſed for the extraction of ſugar from the cane is the ſame as is employed for the extraction of any eſſential ſalt from the juices of plants, with this difference, that as ſugar and liquors containing it are very fermentable, this ſalt is not obtained by a regular cryſtallization, but by a much ſpeedier coagulation.

After having entirely expreſſed the juice from ſugar-canes, it is boiled in caldrons at different times with lime-water and lixivium of aſhes, both to clarify it, and to evaporate it ſo much, that when it cools, moſt of it coagulates or confuſedly cryſtallizes. This coagulated matter is to be ſeparated from the remaining liquor, which is called *melaſſes.* From this liquor, by fermentation and diſtillation, an ardent ſpirit is obtained, called *rum.* The ſolid ſubſtance, or ſugar, is mixed with much mucilaginous extractive matter, which renders it ſoft and red. To purify, or, as it is called, to *refine* it further, it muſt be rediſſolved in pure water, and its heterogeneous parts muſt be ſeparated by boiling with quicklime and lixivium of aſhes, to which is added a certain quantity of ox's blood, for a more perfect clarification and purification. Laſtly, the ſugar, when refined, is put into earthen conical veſſels open at both ends, the ſmaller of which is turned downwards. The ſugar is covered with ſome earth moiſtened with water. This water filtrates through the ſugar, diſſolves the mucilage or ſlime which ſtill adheres to the ſugar, and flows out at the opening in the lower point of the conical veſſel. In this manner is obtained this pleaſant and uſeful ſalt. To whiten and purify it perfectly many clarifications are required; the cauſe of which is chiefly a ſlimy matter, like honey, that adheres to it.

This eſſential ſalt is ſoluble in water, like all other ſalts, and even is one of thoſe ſalts that is ſoluble in the ſmalleſt quantity of water.

It is cryſtallizable; and its cryſtals, when ſlowly and regularly formed, are beautiful and tranſparent, called *ſugar-candy.* This ſalt conſiſts of an acid united with a large quantity of a very attenuated and mucilaginous earth, and with a certain quantity of ſweet and not volatile oil, which is in a ſtate perfectly ſaponaceous, that is, entirely ſoluble in water by means of the acid.

Sugar, when diſtilled, yields a phlegm, an oily empyreumatic acid, a ſmall portion of colored empyreumatic oil, and leaves a conſiderable quantity of reſiduous coal.

This ſalt is very ſuſceptible of the ſpiritous fermentation, when it is diluted in a ſufficient quantity of water; and, like all the other ſubſtances capable of that fermentation, it is very nutritive to animals.

The nutritive and fermentative parts of vegetables have not been ſufficiently examined, to enable us to determine, whether they be perfectly of a ſaccharine nature. We know, however, that they furniſh by analyſis the ſame principles, and nearly in the ſame proportion; that they all have a ſweet, agreeable, and generally ſaccharine taſte; that every vegetable or animal ſubſtance that is ſaccharine is alſo nutritive and fermentative; and, laſtly, that genuine ſugar may be obtained from moſt of them.

Mr.

Mr. Margraaf has obtained ſugar from the roots of ſeveral plants, as from carrots, parſnips, white and red beets. Some of theſe roots, as, for example, the white beet, furniſhed a very conſiderable quantity of ſugar. He obtained about half an ounce of ſugar from half a pound of the dried root. This able chemiſt, conſidering that ſugar is ſoluble in ſpirit of wine, and that the mucilaginous parts of plants are not ſoluble in that fluid, eaſily obtained a pure ſugar by digeſting the dried roots in that ſpirit, and by evaporating the liquor. Afterwards, hoping to find a cheaper method, that his diſcovery might be uſeful, he attempted ſucceſsfully to obtain ſugar by the ordinary proceſs very little varied. He could not indeed obtain a very pure ſugar without repeating very frequently the ſolutions, clarifications, and other operations, as may be ſeen in his Memoir, or in the eighth Diſſertation of his *Opuſcules Chemiques*. But at laſt he did ſucceed; and we have reaſon to hope, that by improving the proceſs, much ſugar may be obtained from other vegetables, as from green peas, cabbage, green farinaceous grains; from ſeveral trees, as the ſycamore, and the birch trees, ſome of which have more of a ſaccharine taſte than ſeveral of the plants from which Mr. Margraaf extracted ſugar.

The chief, and perhaps the only difficulty to be ſurmounted in this extraction of ſugar proceeds from the viſcid matters, which are ſo mixed and blended with the ſaccharine ſubſtance of plants, that they prevent its cryſtallization. The ſaccharine and mucilaginous parts might be ſeparated from each other by means of a menſtruum, which could diſſolve the ſugar and not the ſlimy ſubſtance, or which could diſſolve the latter and not the former. To diſcover ſuch a menſtruum ſeems to be the proper object of inquiry for thoſe who would proſecute this ſubject.

DCLXXII. S U G A R *of* L E A D. *See* Salt *of* Lead.

DCLXXIII. S U G A R *of* M I L K. *See* Milk.

DCLXXIV. S U L P H U R. No word has been ſo much uſed by chemiſts, and at the ſame time ſo much abuſed, as *ſulphur*. By this the ancient chemiſts denoted all inflammable ſubſtances of whatever nature they might be. Sulphur, according to them, is one of the principles of bodies. They ſpoke continually of the ſulphurs of metals, of the ſulphurs of plants, of the ſulphurs of animals: oils, ardent ſpirits, reſins, bitumens, were all ſulphurs. In every thing they found a ſulphur. Even now, alchemiſts and others who have only confuſed ideas of chemiſtry, from reading old chemical books, talk inceſſantly and deciſively of ſulphurs.

To Beccher, and ſtill more to the illuſtrious Stahl, we owe the ſimple, clear, and preciſe ideas which we now have of the ſeveral kinds of inflammable ſubſtances, formerly confounded under the general name of ſulphur. By the ſagacious diſtinction they have made between the pure and ſimple inflammable principle, and the more compounded bodies which contain it, and owe their inflammability to it, we acquire a knowledge of the true theory of ſulphur and of all inflammable ſubſtances.

Since Stahl has unfolded this ſublime theory, we know that the inflammable principle is identical, always alike, and the ſame in every body; that this principle by its combination with different ſubſtances produces all the inflammable matters which we know. Oils, fats, reſins, bitumens, ardent ſpirits, coals, metals, ſulphur properly ſo called, or common ſulphur, are ſo many com-

compounds, all which have the common property of burning, becauſe they all contain the principle of inflammability, but which differ in other reſpects, becauſe this principle is united to different ſubſtances, and in different proportions.

Stahl has eſtabliſhed theſe important truths, chiefly by examining, by decompoſing, and by re-compoſing common ſulphur, and by demonſtrating from the moſt ſatisfactory experiments, that this ſulphur conſiſts of vitriolic acid united with the pureſt and ſimpleſt inflammable principle. We ſhall relate as ſhortly as we can the reſults of his reſearches upon this ſubject.

Nature probably forms, and combines daily, mineral ſulphur within the earth. This ſubſtance is abundantly diffuſed in many places, eſpecially where metallic minerals exiſt. Sulphur almoſt pure, called *native ſulphur*, is found in volcanos and in grottos, where it is ſublimed in form of tranſparent cryſtals. But the greateſt quantity of ſulphur which exiſts naturally is combined with metals in ores and eſpecially in pyrites. As ſulphur is fuſible and volatile, it is procured from theſe minerals by diſtillation and ſublimation. *See* SMELTING *of* ORES.

Sulphur, ſuch as it is in commerce and in arts, is of a pale yellow or citron color, of a diſagreeable and peculiar ſmell, which is rendered more ſenſible when the ſulphur is heated or rubbed. By rubbing, ſulphur is electriſed. Its ſpecific gravity is much greater than that of water, and leſs than that of earths and ſtones. It is brittle and pulverable; altho' it may alſo be eaſily ſoftened, as we ſhall afterwards obſerve.

Sulphur ſeems to be incapable of receiving any alteration from air or from water, ſeparately or conjointly, nor even from fire in cloſe veſſels. Sulphur, expoſed to heat in a ſubliming veſſel, is melted with a very gentle heat, and then is ſublimed, and adheres to the capital, forming ſmall very fine needle-like cryſtals, called *flowers of ſulphur*. This ſublimed ſulphur is eſſentially the ſame as that which has been only melted: and it may be thus ſublimed many times without alteration. If ſulphur, which has been expoſed to no more heat than ſufficient to melt it, be cooled very gradually, it cryſtallizes in form of many needles croſſing each other. Some of theſe pointed cryſtals may alſo be obſerved in the interior parts of the lumps of ſulphur which have been melted and caſt into cylindrical moulds, as they are commonly ſold; becauſe the center of theſe cylindrical rolls is more ſlowly cooled than the ſurface. Sulphur alſo gives this needle-like form to cinnabar, to antimony, and to many other minerals containing it.

Sulphur is inflamed and burnt by expoſure to fire and to air. But the phenomena which it exhibits are different according to the manner of its combuſtion. When it is very hot and burns quickly, its flame is ardent and capable of kindling inflammable bodies, but is always blueiſh, not very luminous, and not accompanied with any ſoot or ſmoke, but with an acid vapor of a penetrating and ſuffocating ſmell. This vapor, confined by means of a glaſs bell, and received into the vapor of water, introduced for that purpoſe into the ſame bell, is called *ſpirit of ſulphur*, which we ſhall afterwards ſhew is the vitriolic acid, that is at firſt volatile and ſulphureous, from the ſmall quantity of inflammable principle that it ſtill retains, but which afterwards becomes pure vitriolic acid.

If

If, on the contrary, sulphur is burnt in open air but very slowly, its flame is so little luminous, that it can be perceived only in the dark, like a small bluish glimmering light; and so little ardent, that it cannot kindle the most inflammable substances. Mr. Beaumé proves this truth by a very fine and curious experiment, in which he burns all the sulphur that is contained in gun-powder without kindling the powder. When this experiment is made, a tile must be equally heated and to a certain degree, that is, a little more than is requisite for the success of the experiment. Upon this tile, thus heated, some grains of gun-powder are thrown, to discover the degree of heat; and if the heat be too great, the powder detonates, from time to time, as is usual. More powder is thrown on the tile, till this be so much cooled, that the powder does not fulminate, but only emits a white smoke. If the tile and powder be carried in this state to a dark place, the vapor, which seemed to be a white smoke, will then appear to be a true flame, but very bluish and faint; which will continue till all the sulphur of the powder be consumed, if the tile remains sufficiently hot for that purpose.

We may easily perceive, that when the sulphur burns thus weakly and slowly, a part of its inflammable principle is dissipated without inflammation, and that consequently the acid which is disengaged by that combustion, ought to be more volatile, penetrating, and sulphureous, than it is when the inflammation is more rapid. Hence, when we would obtain much volatile sulphureous acid by burning sulphur, as for the whitening of stuffs by the vapor of sulphur, it must be burnt very slowly, as Stahl has well remarked.

As nothing remains after the burning of sulphur, unless some extraneous body happens to be mixed with it; and as, during this combustion, nothing is perceptible but two matters, one of which is destroyed by the inflammation, and another which has the properties of the vitriolic acid; we may conclude, that sulphur is composed of an inflammable matter, and of vitriolic acid. But the examination of the other properties of this substance will render our knowledge of its nature and its principles more compleat and accurate.

Sulphur heated so much as to burn, and thrown while melted and burning into water, is very quickly fixed or rendered solid; but in this experiment it acquires a considerable degree of softness, which indeed only lasts a certain time; after which the sulphur recovers its natural consistence and brittleness.

Pure acids seem to have no action upon sulphur, especially in the humid way. But Mr. Beaumé has observed, that if concentrated vitriolic acid be poured upon sulphur, and heated to a certain degree, this sulphur will liquefy and appear in the water like an oil; and when it is cooled, it will have a green color; which seems to shew some action of the acid upon the sulphur. But this sulphur is not in any other respect changed.

Alkalis fixed and volatile, and even calcareous earths, dissolve sulphur, render it more or less soluble in water, and form with it compounds called *livers of sulphur*. The sulphur may be separated and precipitated, by means of an acid, from these substances; in which case, it appears as before, only much divided.

This experiment shews that sulphur is not decomposed by uniting with alkalis. Nevertheless the strong fetid smell of liver of sulphur, and the fa-

cility of decomposing sulphur while it is thus united with an alkali, shew that, in this combination, the connexion of its parts are weaker than when it is uncombined. *See* LIVER *of* SULPHUR.

Sulphur detonates with nitre, from its inflammable principle, and is then decomposed by the combustion of this principle. But in this detonation we perceive only the two principles of sulphur above-mentioned. Its phlogiston, together with that of the nitrous acid, maintains the flame of this detonation, and the acid of the sulphur is afterwards found to be combined with the alkali of the nitre, with which it forms a vitriolated tartar, called *sal polychrest of Glaser*. This is completely proved in the experiment of the *clyssus of sulphur*. *See* CLYSSUS.

Sulphur unites easily with all metallic matters, excepting gold, platina, and zinc; at least we have not found the means of uniting it with these, directly, and without some intermediate substance. The degrees of affinity with which sulphur combines with those metals to which it may be readily united, are different; for it not only unites more easily and abundantly with some than with others, but it also quits those with which it has a less affinity, to unite with others to which it has a stronger affinity.

The affinities of sulphur according to Mr. Geoffroy's table are, fixed alkali, iron, copper, lead, silver, regulus of antimony, mercury, and gold; and according to Mr. Gellert's table, they are, iron, copper, tin, lead, silver, bismuth, regulus of antimony, mercury, arsenic, and cobalt: gold and zinc are marked in this table as being incapable of uniting with sulphur.

The compounds formed by sulphur with different metals are different; but all of them possess a metallic lustre, without any ductility: these combinations of sulphur and of metals are very frequently found in a natural state. Almost all the metals which we dig from the earth are naturally found combined with sulphur, forming most of the ores and metallic minerals.

The properties of the combinations of sulphur with metallic matters have been little examined, because these combinations are not of any use; but, on the contrary, when they are found, they must be decomposed, that the metals may be obtained separately from the sulphur. Nevertheless, we know not only that metals have different degrees of affinity with sulphur; in consequence of which property, sulphur may be and actually is, in many metallurgical operations, separated from some metals by means of others, to which it is more disposed to unite; but we also know that sulphur facilitates the fusion of hard and difficultly fusible metals, such as copper and iron; and that, on the contrary, it renders the soft and fusible metals, as tin and lead, less easily fusible. These singular effects seem to proceed from the difference of the affinity of sulphur to the several metals.

Sulphur may be separated from metallic matters by several methods. First, as sulphur is volatile, and as these metallic matters are fixed, or at least less volatile than sulphur, the mere action of fire is sufficient to separate sulphur from most metals. As this method is simple, and not expensive, it is generally employed to separate sulphur from ores; which effect is produced by the *torrefaction* or *roasting* of these ores. We must, however, except the ore of mercury, or native cinnabar, and also the combinations of arsenic with sulphur, which cannot be decomposed without an intermediate substance, from the great volatility of mercury and of arsenic: although perhaps it would not be impossible

possible to separate the sulphur from these compounds, without an intermediate substance, by a heat carefully applied, long continued, and with access of air.

Secondly, several combinations of sulphur with metals may be decomposed by means of acids, which dissolve the metallic matter, without attacking the sulphur. But in several of these compounds, the sulphur defends the metal from the action of the acids; and this separation by acids does frequently not succeed, or succeeds only imperfectly. Crude antimony is one of the sulphurated metallic substances from which sulphur may most easily be separated by means of aqua regia. This menstruum seizes readily the regulus of antimony contained in mineral antimony, and separates from it the sulphur, which then appears in form of a white powder.

Lastly, we may, as we have already said, separate several metals from sulphur by means of other metals, to which the sulphur has a greater affinity. This separation is practised in several operations, as in the *dry parting*, the *purification of gold by antimony*, the *decomposition of cinnabar*, of *orpiment*, and of *crude antimony*. *See the articles* ESSAY *of* ORES; ORES; PYRITES; SMELTING *of* ORES; *and all the articles of the several metals and semi-metals.*

Oils and oily matters, of whatever nature, are all capable of acting upon sulphur, and of dissolving it. Several solutions of sulphur in essential oils are used in pharmacy, which have been named from the oils employed; as *terebinthinated balsam of sulphur*, and *anisated balsam of sulphur*; and other solutions have been made of sulphur in expressed sweet oils, as that in the oil of nuts, called *Rulland's balsam of sulphur*.

Sulphur cannot be dissolved in oils, according to Mr. Beaumé, without a heat sufficient to melt it. A larger quantity of sulphur is kept dissolved in the oil while hot than when cold; and accordingly when oil has been saturated with sulphur by means of heat, a part of the sulphur separates from it when it cools, in the same manner as many salts kept dissolved in hot water are crystallized when the water becomes cold. The analogy betwixt the salts and sulphur in these instances is also observable in this respect, that when the oil in which the sulphur is dissolved is very gradually cooled, the sulphur crystallizes regularly, as salts do in similar circumstances.

Sulphur is not decomposed by the union which it contracts with oils, when no more heat is applied than is necessary for the solution. For the sulphur, when separated from the oil, is found to be possessed of all its properties. It appears, however, that the connexion of its principles is in some measure altered by this combination; at least, if we may judge from the color and smell of the balsams of sulphur which are different from those of the sulphur, or of the oil.

But when the balsams of sulphur are distilled with a heat capable of entirely decomposing them, the sulphur itself is then also decomposed. For according to an experiment made by Homberg, and some other chemists, the same principles are obtained by this distillation continued till the matter in the retort be dry, as are obtained from a combination of pure vitriolic acid with oils. These principles are, first, a portion of oil, when the oil of which the distilled balsam is composed was an essential oil; then some volatile sulphureous acid, which is at first watery, and afterwards becomes stronger; along with this acid more oil rises,

rises, which becomes more and more thick towards the end of the distillation; and lastly, when the retort has been red-hot, nothing remains but a fixed coal.

From the above-mentioned products we find, that the sulphur and part of the oil are decomposed in this distillation. The vitriolic or sulphureous acid certainly proceeds from the sulphur: for no quantity of that acid can be obtained from any kind of oil, nor from any pure vegetable or animal oily matter. The water contained in this sulphureous acid is evidently a part of the water which is a principle of the oil: for the vitriolic acid of the sulphur being in a state perfectly concentrated and dry, as shall be afterwards shewn, could not otherwise contain so much water as it does in this operation. Lastly, the coal which remains after the operation is a portion of the earth that is a principle of the oil, intimately united with some of the inflammable principle either of the oil or of the sulphur, or most probably of both.

In this mutual decomposition of sulphur and oil, the concentrated acid of the sulphur seems to attack the watery principle of the oil, while its phlogiston, which by this new union loses much of its adhesive power, is partly disengaged, and confounded with the phlogiston of the oil. Thus the sulphur is changed into volatile sulphureous acid. And probably also a certain quantity of inflammable principle is disengaged in this experiment, and is dissipated in vapors. Such appear to be the phlogistic vapors, which, kindling at once, produce the terrible explosions that sometimes happen when the combinations of oil and of sulphur are carelesly heated. Hoffman relates a singular instance of an explosion of this kind, which happened in a laboratory, where balsam of sulphur had been left in a matrass upon the fire.

Spirit of wine does not act sensibly upon sulphur, unless these two substances be applied to each other in the state of vapor, as the Count de Lauraguais discovered. Many combinations, now believed to be impossible, might be effected by employing the most powerful means in chemistry; namely, an extreme division and separation of integrant parts, as the Count de Lauraguais has done in the abovementioned fine experiment. By this means, chiefly, we may arrive at great discoveries. From the above-mentioned properties of sulphur we learn, that this substance is composed of vitriolic acid and phlogiston. Stahl demonstrated this important truth so clearly and compleatly, as to shew the true state, and even the proportion of the principles of sulphur, not only from its analysis, but also by its artificial composition, of which we shall now speak.

The process by which this chemist made sulphur exactly similar to native sulphur, consists in mixing and melting together in a crucible equal parts of fixed alkali and of vitriolated tartar, to which is added a quantity of powdered charcoal equal to a fourth part of the weight of the salts. The matter is to be stirred with an iron rod, that the charcoal may be well mixed with the salts; the crucible is to be covered; and a pretty strong heat is to be suddenly applied, and continued during a very short time. The crucible is then to be removed from the fire, and the melted matter is to be poured upon a stone previously greased. This matter, which sparkles when it is poured, is coagulated by cold, and becomes a brittle mass, of a deeper red color than ordinary liver of sulphur; but it has the smell, the solubility, the deliquescency,

deliquescency, and all the other properties of liver of sulphur. By dissolving it in water, and by adding any acid to the solution, an artificial sulphur will be precipitated, which being collected and dried, is found not to differ from natural sulphur.

The color of this dry liver of sulphur is redder than that of the ordinary preparation of that name; and when dissolved in water, its solution its of a deep green color, in which respect also it differs from the ordinary liver of sulphur. These differences proceed from some foreign matter united with the liver of artificial sulphur; and this foreign matter is a part of the charcoal employed in the process for making the sulphur. For the whole quantity of charcoal added not being converted into sulphur in this process, some part of it is dissolved by the liver of sulphur, as soon as this is formed; charcoal being soluble in liver of sulphur, as the younger Mr. Rouelle has shewn.

We should be much mistaken if we believed, that the sulphur obtained in this operation existed ready formed in any of the substances employed, and that it is only extracted from these. Glauber had, before Stahl, performed this operation, by employing his *sal mirabile* instead of vitriolated tartar; but from his ignorance of the true theory, he fell into this mistaken opinion. Boyle also, having procured sulphur by distilling to dryness a mixture of vitriolic acid and oil of turpentine, did not believe that he had produced this sulphur, but only that he had separated it from the substances employed. On the contrary, we know certainly from many proofs, that not a particle of sulphur exists in vitriolic acid, nor in neutral vitriolic salts with basis of fixed alkali, nor in very pure alkalis, nor in any oil, nor in any vegetable coal; and consequently the sulphur obtained in these operations is a new product, resulting from the union of the vitriolic acid with the inflammable principle of the vegetable coal, as Stahl has advanced.

The fixed alkali mixed with the vitriolated tartar in this process is not absolutely necessary; for sulphur may be produced merely from any vitriolic salt with any inflammable matter, made red-hot together: but the alkali is useful in this process, by facilitating the fusion of the vitriolated tartar, and by preventing the dissipation and combustion of most of the sulphur, as soon as it is formed. This alkali unites with this sulphur, and forms a liver, in which the sulphur is less disposed to burn, and be dissipated, than when it is not engaged with any fixed and incombustible body.

Although, rigorously speaking, the vitriolic acid itself, when disengaged, and treated properly with any combustible body, can always produce sulphur; nevertheless, in this operation, an acid engaged in some basis to which it adheres strongly ought always to be employed; such is the acid in vitriolated tartar, in Glauber's salt, and even in almost all neutral vitriolic salts with earthy and metallic bases; because vitriolic acid cannot contract with the inflammable principle the intimate union which is requisite for the production of true sulphur, excepting it be deprived of all the water that is not necessary to its saline essence; that is to say, in its highest degree of concentration, and even in a dry state. Besides, if a red heat be not absolutely necessary to effect this combination, as the sulphur formed in the solution of some metallic matters by vitriolic acid shews, it

it is nevertheless very useful. But when a disengaged vitriolic acid is employed; as, for instance, when a mixture of this acid with an oil is distilled; the greatest part of the acid is converted into volatile sulphureous acid, while any moisture remains in the mixture, and the sulphur is not produced till towards the end of the operation, when the matter in the retort is dry; and then the concentrated remaining portion of vitriolic acid, uniting with the phlogiston of the earthy coal of the oil, forms the sulphur.

Hence, sulphur may be more copiously and quickly made by applying to a coal vitriolic acid engaged in some basis, which renders it so fixed that it may, by fire, be deprived of all superfluous water, and even be made red-hot, than by employing this acid in any other manner. Accordingly Stahl's process is the best. These considerations on the best method of making sulphur are of little value, because natural sulphur is plentiful and cheap. But the discovery that sulphur can be thus made, and the theory which Stahl has given concerning this subject, are very important. For from thence we not only learn the nature of sulphur, of which we had an imperfect, and even false, idea; but, what is much more valuable, we may thence draw a number of very important and very general inferences, the chief of which we shall now mention.

First, vitriolic acid and the inflammable principle cannot form sulphur by combining together, unless they both be deprived of all moisture, and be perfectly dry. Hence no inflammable body which contains in its composition water, such as oils and ardent spirits, can form with this acid, sulphur, but only a volatile sulphureous acid, till these inflammable matters be decomposed, and reduced to a state of coal, which is one of the dry combinations of the inflammable principle.

Secondly, the inflammable principle of all combustible bodies is always capable of forming sulphur with the vitriolic acid, provided it be, or can be made, dry. Thus ardent spirits, oils, and oily matters, or rather the coals of all these substances, and all combustible metals, do always form sulphur when treated properly with vitriolic acid; and whatever the nature of the combustible body be which transfers the phlogiston to the acid, the sulphur resulting from it is always the same, and always perfectly similar to natural sulphur. Hence an important proposition is inferred, that only one inflammable principle exists, which is always the same, whether it resides in resins, in bitumens, in oils and fat, in coals, or in metals. For if the inflammable principle of all these combustible bodies was not the same principle, these bodies might form different sulphurs with vitriolic acid, which we find from experience they cannot do.

Thirdly, vitriolic acid always quits any body with which it happens to be combined, when it can unite with the inflammable principle of any other body, and with this principle forms sulphur when it is properly applied. Hence, this acid has a greater affinity with the inflammable principle than with any other substance; and hence we may discover, by means of phlogiston, the vitriolic acid, with whatever substances it may be combined; and reciprocally we may, by means of vitriolic acid, discover the inflammable principle in all bodies in which it exists in a combustible state.

Fourthly, the principles and properties of sulphur being known, we may deduce from these properties a more accurate knowledge of the particular nature of

of the inflammable principle, by comparing the differences between sulphur, volatile sulphureous acid, and pure vitriolic acid. From this comparison we find that the smell and color of sulphur, its volatility, its constant dryness, its unsolubility in water, which properties do not belong to vitriolic acid, are produced by the inflammable principle, that possesses all these qualities in itself, or that is, at least, capable of communicating them to the compounds in the combination of which it enters. *See the Article* PHLOGISTON.

Fifthly, we have reason to believe that the inflammable principle possesses eminently the abovementioned properties; for we know that the quantity of it in sulphur is much less than the quantity of the vitriolic acid. Stahl has made a fine experiment to discover nearly the proportion of the two principles of sulphur. This experiment consists in putting a quantity of powdered liver of sulphur upon an earthen-ware plate, and placing this plate upon a fire so gentle that the liver of sulphur shall not be melted, nor even so softened that it can run into lumps. This powder must be stirred, and the fire must be encreased towards the end, till no smell be perceived. The remaining matter is to be dissolved in water, and by crystallization a very pure vitriolated tartar is formed.

In this operation, the inflammable principle of the sulphur is gradually dissipated without any sensible combustion, and its acid combines, or remains combined, with the alkali of the liver of sulphur. But we must observe, that to render this experiment exact, and to draw from it accurate conclusions, the following conditions are required: 1st, we must know precisely the quantity of sulphur contained in the liver of sulphur employed; 2dly, the liver ought to contain rather too much than too little fixed alkali, that there may be certainly enough of it to saturate all the acid of the sulphur; lastly, no part of the sulphureous acid must escape during this decomposition; and therefore no smell of this acid, but only that of the liver of sulphur, which is very different, ought to be perceived. To prevent this dissipation of volatile acid, we must proceed very slowly; and the operation accordingly requires a long time. Mr. Brandt, who has carefully repeated it, found from the quantity of vitriolated tartar obtained by this method, that, in sulphur, the proportion of inflammable principle is to that of the vitriolic acid as three to fifty; that is, that the sulphur contains only one-sixteenth of its weight of inflammable principle.

Such is the state of our actual knowledge concerning the nature and principles of sulphur, which Stahl has rendered very compleat and accurate. We find that sulphur is a peculiar combination of the purest inflammable principle with vitriolic acid; that not a particle of oil is contained in it; that it is therefore very different from bitumens, with which it has been long confounded; that, still more improperly, the name of sulphur has been given to all other inflammable bodies, which are entirely different from it; that we ought therefore to confine the name of sulphur to the compound formed of pure vitriolic acid and pure phlogiston, unless we would apply it, as the ancient chemists have done, to the inflammable principle itself, which they called the *principal sulphur*; but in this case we ought to give another name to mineral sulphur.

Let us remark, nevertheless, on the subject of the name *sulphur*, that as other acids besides the vitriolic can also contract an intimate union, and form compounds with pure phlogiston, this name may be generally applied to all

compounds

compounds of pure acid and phlogiston, which may be distinguished from each other by adding the name of the acid; as *vitriolic sulphur*, *nitrous sulphur*, and *marine sulphur*, if any such sulphur does exist: but let us also remark upon this subject, that we can give this name of *sulphur* to those compounds only which do not contain any oil; this condition being essential to the sulphureous combination; and consequently, that we cannot admit of *acetous sulphur*, of *tartareous sulphur*, or of others of this nature containing vegetable acids, which cannot ever form a truly sulphureous combination, on account of the oil which enters into their composition as an essential principle. *See the articles* ACID (VITRIOLIC), ACID (VOLATILE SULPHUREOUS), DETONATION *of* NITRE, LIVER *of* SULPHUR, *and* PHLOGISTON.

The uses of sulphur are considerably extensive in chemistry, in medicine, and in arts. The liver of sulphur is employed in chemistry for several solutions, which may be seen at the article LIVER *of* SULPHUR. Sulphur is also useful for several fusions, precipitations, and separations of metals and minerals, as we have already mentioned. Lastly, as sulphur contains a very large quantity of vitriolic acid, a method has been found, and is now practised, of extracting from it this acid, by burning sulphur in close vessels with the addition of some nitre, and by an operation similar to that of the clyssus. *See* CLYSSUS.

Sulphur is employed in medicine, both internally and externally, for asthmatic diseases of the breast, and for several diseases of the skin of the nature of the itch. The internal preparations of sulphur are, flowers of sulphur, washed sulphur, magistery of sulphur, tablets, balsams, livers of sulphur, and others, in some of which this substance is not altered, but only purified and divided, and in others, is combined and associated with other substances; without reckoning the sulphureous combinations of antimony and of mercury.

Some physicians and chemists, considering that sulphur is unsoluble in water, and capable of resisting the action of most menstruums, have advanced that it can produce no effect when taken internally, single and unaltered: but this assertion seems to be without foundation; for we are certain that the sweat and perspiration of those who take sulphur internally have a smell evidently sulphureous. Besides, sulphur is much more soluble than is generally believed. It is attacked by all oily and saponaceous substances, and consequently by almost all animal liquors.

We cannot easily form a very distinct and clear idea of the manner in which sulphur acts internally upon our bodies; but from observations made upon its effects, it appears to be dividing, stimulating, and somewhat heating: it principally acts upon the perspirable parts of the body, the chief of which are the skin and lungs; and from this property, it is particularly useful in some diseases of these parts.

Sulphur is also a powerful repellent, as appears from its curing several kinds of itch merely by external application in form of ointments and pomatums.

Several mineral waters, which are drank, or used as baths, for some diseases, owe their good qualities to sulphur contained in them. Such are the waters of Cauterets, of Mont D'or, of Aix-la-Chapelle, and of Saint-Amant. Accordingly, these waters are employed in several diseases of the breast and of the skin.

ſkin. Laſtly, ſulphur combined with other ſubſtances may contribute to their medicinal powers. *See the articles* BALSAM *of* SULPHUR, CINNABAR, ETHIOPS MINERAL, MINERAL WATERS, LIVER *of* SULPHUR, KERMES MINERAL.

Sulphur is alſo uſed in ſeveral arts. By means of it fine impreſſions of engraved ſtones are taken. Matches are formed of it; and its utility as an ingredient in the preparation of gun-powder and fire-works is well known. Laſtly, it is uſed for whitening wool, ſilk, and many other matters expoſed to its vapor during its combuſtion, the colors and redneſs of which could not be deſtroyed by any other ſubſtance, but are quickly effaced by this acid vapor.

DCLXXV. SULPHUR (GOLDEN) *of* ANTIMONY. Golden ſulphur of antimony is a mixture of ſulphur and regulus of antimony, of an orange color, which is obtained by diſſolving the ſcoria of regulus of antimony, and by precipitating this ſolution by means of an acid.

We may ſee at the article REGULUS *of* ANTIMONY, that this ſcoria is a liver of ſulphur, containing a certain quantity of the reguline part of antimony. When therefore this antimoniated liver of ſulphur is diſſolved in water, and when any acid is added to this ſolution, the acid ſeizes upon the alkali of the liver of ſulphur, by means of which the ſulphureous and reguline parts of the antimony were kept ſuſpended in the water, and at once precipitates both theſe.

Although this precipitate be compoſed of ſulphur and regulus of antimony, as crude antimony alſo is, its properties are nevertheleſs very different from thoſe of this mineral. The precipitate has no metallic color or appearance, and is beſides poſſeſſed of a powerful emetic quality, which the antimony has not. Theſe differences proceed from the ſulphur of the precipitate not being united with the reguline part in the ſame manner, nor ſo intimately, as in crude antimony. In the golden ſulphur, the reguline part is only *mixed* with the ſulphur, and is in a great meaſure diſengaged and uncombined; whereas in crude antimony, it is intimately connected and united with the ſulphur.

Golden ſulphur has ſome reſemblance to kermes mineral: but it differs eſſentially in ſome circumſtances, namely, that a ſmall portion of fixed alkali remains united with the kermes when well prepared, that is, not too much waſhed, and that the proportion of ſulphur is greater in kermes than in the golden ſulphur. To be convinced of theſe differences, we need only to attend to the circumſtances which accompany the precipitation of theſe two ſubſtances. Kermes is precipitated ſpontaneouſly without addition of any acid, and merely by the cooling of the ſolution of the antimoniated liver of ſulphur which contains it: it is therefore compoſed of the reguline part, but eſpecially of the ſuperabundant quantity of ſulphur, which the alkali cannot keep diſſolved, but by means of a heat almoſt equal to that of boiling water: whereas the ſolutions of antimoniated liver of ſulphur, not only that of kermes itſelf, but alſo that of the ſcoria of the regulus of antimony which has depoſited its kermes by cooling, contain no more ſulphur than the alkali can keep diſſolved without heat, which quantity is therefore leſs than in the kermes. Beſides, the acid neceſſary for the precipitation of the golden ſulphur ſeizes all the

alkali; whereas a little of it always adheres to the kermes during its precipitation.

The golden ſulphur of antimony was much employed when preparations of antimony were firſt introduced into medicine, but is now pretty much neglected; and juſtly, becauſe the kermes and emetic tartar produce the ſame effects more gently and more uniformly. *See* ANTIMONY *and* KERMES (MINERAL).

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DCLXXVI. TALK. *See* MICA.

DCLXXVII. TAR. *See* PITCH.

DCLXXVIII. TARTAR. Tartar is a concrete, oily, vegetable acid, which is deposited and is crystallized in liquors that have undergone the spirituous fermentation. It is a kind of essential salt of wine.

Probably wines of all kinds deposite a greater or less quantity of tartar; but the wine of grapes is one of those which furnish the most of it, and the tartar of this wine is almost the only one that is employed or known.

All wines of grapes do not furnish an equal quantity of tartar. Some of them deposite it abundantly, and others but a small quantity only. Sometimes a longer and sometimes a shorter time is required for the deposition of tartar. Generally a long time is required, and also an insensible kind of fermentation, which continues in the wine a long time after the signs of the sensible spirituous fermentation have ceased. *See* WINE.

The tartar is deposited on the sides of the casks containing wine. On these a hard crust is formed, which becomes more and more thick; and as a portion of the fine dregs of the wine adheres to this crust, the tartar of white wine is of a greyish-white color, and is called *white tartar*; and that of red wine has a red color, and is called *red tartar*.

Tartar, when separated from the casks on which it is formed, is mixed with much heterogeneous matter, from which it is purified for the purposes of medicine and of chemistry. This purification of tartar is performed at Montpellier, and consists (as we find from a Memoir of M. Fizes, Professor of Medicine at Montpellier, printed amongst the Memoirs of the Academy for the year 1725) in boiling tartar in pure water, in filtrating this water, and in allowing the saline matter to deposite by cold. By this first operation, the grosser impurities which adhere but slightly to the tartar are separated: but the

cryſtals obtained by this operation are ſtill red, and charged with an oily matter extraneous to the tartar.

From this extraneous matter the tartar is purified by boiling it in water in which clay is diffuſed By a ſecond filtration and cryſtallization, very pure and white cryſtals of tartar are obtained; but they are ſmall and ill-ſhaped, from the quickneſs of their formation.

This cryſtallization is partly performed by evaporation, and partly by cold. The part which cryſtallizes by evaporation forms a ſaline cruſt upon the ſurface of the liquor, called *cream of tartar*; and the part which cryſtallizes by cold forms ſmall irregular cryſtals, called *cryſtals of tartar*; but the name of cream of tartar has prevailed over the latter; ſo that it is at preſent applied alſo to cryſtals of tartar, and ſignifies in general purified tartar.

Cream of tartar has a taſte ſenſibly acid; it reddens the blue colors of vegetables; it may be ſaturated by uniting with any of thoſe ſubſtances which are capable of forming with acids neutral ſalts; and it may be afterwards ſeparated from theſe ſubſtances, and may recover its former appearance. Accordingly, we are certain that this ſaline matter is an acid. Its property by which it is concrete and cryſtallizable, it receives from a portion of earth and oil, with which it is intimately combined, and which approximate it to the nature of neutral ſalts, eſpecially in what concerns the cryſtallizable quality and the ſolubility of theſe ſalts.

Tartar, although acid, is not very ſoluble in water; it is even much leſs ſoluble than moſt of the perfectly neutral ſalts. According to Mr. Spielman's experiment, an ounce of diſtilled water can diſſolve only three grains of cream of tartar, with the heat of fifty degrees of Fahrenheit's thermometer, which is equivalent to the tenth degree of Mr. Reaumur's. By help of a boiling heat, water diſſolves much more tartar; but this tartar cryſtallizes very quickly when the water ceaſes to boil. The oily part of the tartar ſeems to be the chief cauſe of its difficult ſolubility in water.

Tartar is in a great meaſure decompoſed and totally changed by the action of fire. If cream of tartar be diſtilled in a retort with a naked fire, a little phlegm will firſt riſe with a gentle heat. When the fire is gradually encreaſed, which muſt be done very cautiouſly, on account of the prodigious quantity of air that is diſengaged during this diſtillation, an acid ariſes in form of white vapors, which are accompanied with an oil, at firſt thin, but afterwards more and more colored and empyreumatic. In the retort there remains a coal, ſtrongly alkaline, equal in weight to two-thirds of the tartar employed.

The acid obtained in this diſtillation is indeed oily, and therefore retains the character of a vegetable acid; but it is very different from the tartar itſelf. It is no longer cryſtallizable; it is only an oily empyreumatic acid, ſimilar to what is obtained from all other vegetables by diſtillation in a naked fire. Theſe differences muſt be attributed to the portion of oil and of earth, which are ſeparated from this acid by diſtillation. As to the reſiduum of coal, the fixed alkali, which it contains ready formed, is remarkable, conſidering that here there is no incineration in open fire, which is generally neceſſary for the production of alkali from almoſt all other vegetables. The cauſe of this difference probably is, that the acid of tartar is almoſt entirely changed into fixed alkali, as more diſpoſed to be alkaliſed than any other vegetable acid, whether this diſpoſition

dispofition proceed from the quantity of earth and oil which are intimately mixed with it, or from some change produced upon it by fermentation. Mr. Spielman thinks, with much probability, that acids are changed into alkalis by the substraction of a part of their aqueous principle: and the nature and proportion of the constituent parts of tartar appear to be very proper to favor this substraction of the watery principle by the action of fire. This subject is still obscure, and would require a more profound examination.

DCLXXIX. TARTAR EMETIC, *or* STIBIATED TARTAR. Thus is named the compound formed of the acid of tartar combined with the metallic part of antimony, when this is half deprived of its phlogiston. It is the best and most used of all the emetic preparations of antimony, because the metallic part of this mineral, which gives the emetic quality, is in a saline state, and is perfectly soluble in water.

This preparation has been justly substituted for the golden sulphur, for the regulus, for the liver and glass of antimony, and for the powder of Algaroth. It is infinitely preferable to these preparations for the reasons mentioned; but unfortunately, the method of preparing this important remedy has not been fixed and determined. If in fact we consult the several dispensatories, we shall find very different processes directed: the cream of tartar is employed by all; but some of them require that it should be boiled with the liver of antimony, others with the glass of antimony, and lastly, some with both these preparations. The proportion also of the ingredients, the length of time of boiling, the method of crystallizing and drying the salt after it has been boiled, are different in different dispensatories. In whatever manner cream of tartar is treated with the abovementioned preparations of antimony, we always obtain an emetic tartar much preferable to the ancient emetic preparations of antimony. But we are also certain that the emetic tartars obtained by these several processes are sometimes more and sometimes less emetic; which difference is certainly a great inconvenience for so important a medicinal preparation as this is.

Probably this diversity has been occasioned by persons not considering, or not knowing, that the emetic quality of this preparation proceeds from the metallic earth being dissolved by the acid of tartar, and forming with it a kind of soluble tartar, a true neutral salt, no less capable of a very exact saturation than the vegetable salt, the salt of Saignette, and all the other soluble tartars. For this saturation being a fixed point, and easily to be found, would probably have been universally prescribed, as is done for all other neutral salts, if it had been well known to have occurred in this instance. But as it is now sufficiently ascertained, we may hope that all the faculties of medicine will adopt it, that there may be hereafter only one kind of emetic tartar, always equally strong. Upon this subject we shall add some observations.

First, although regulus of antimony be essentially emetic, it nevertheless produces less effect than the liver or the glass of antimony, because it is less soluble. These two preparations, which are only the metallic earth of antimony deprived of a part of phlogiston necessary to the reguline state, are for that reason more easily soluble by acids than the regulus, and are consequently more emetic. But the glass is still more emetic than the liver, because it has less phlogiston; and it accordingly seems to be the most emetic,

and moſt ſoluble in acids, of all the preparations made by fire of this mineral.

Secondly, the end propoſed in making emetic tartar, is to obtain an emetic preparation of antimony, in which the metallic earth is united with an acid, and is ſoluble in water by means of that acid, and thus is exempted from the inconveniences of the ancient antimonial emetics, the glaſs, the liver, &c. The principal inconvenience of theſe emetics is, that their effects are very uncertain. Sometimes theſe effects are not ſufficiently ſtrong, but are more frequently too violent. Theſe differences of the ſame medicinal preparation, given in the ſame doſes, ſhew that the circumſtances on which their action depends are variable. They cannot act internally, till they are diſſolved: they can only be diſſolved by the acid or other liquors of the body that are capable of attracting them: But the quantity and ſtrength of theſe diſſolving liquors in the body are very variable, according to the different conſtitutions and ſtates of the alimentary canal. Beſides, the greater or leſs diviſion of theſe antimonial preparations favors more or leſs their ſolution in the body. We need not therefore wonder that their emetic effects ſhould be ſo variable and uncertain.

Theſe inconveniences are avoided by giving a ſaline quality to antimonial emetics, by uniting them with the acid of tartar. They then become entirely ſoluble in water by means of this acid; and the whole quantity of them which is adminiſtered produces conſtant and uniform effects: hence emetic tartar is preferable to all other antimonials that are not in a ſaline ſtate. But this preparation alſo muſt be more or leſs emetic, according to the quantity of reguline or metallic earth which it contains. Accordingly, Mr. Geoffroy found by examination of ſeveral emetic tartars, that an ounce of the weakeſt of theſe contained from thirty to ninety grains of regulus, that an ounce of moderate ſtrength contained about 108 grains, and that an ounce of the ſtrongeſt kind contained 154 grains of regulus. The detail of his experiments may be ſeen in the Memoirs of the Academy for the year 1734.

Theſe differences of ſtrength muſt proceed from the different methods employed to prepare the emetic tartars, and from the more or leſs perfect ſaturation of the acid of tartar.

M. Beaumé affirms from experiment, that this acid may be eaſily ſaturated with the reguline part of antimony: and as the glaſs of antimony is the moſt emetic and moſt ſoluble of all the antimonial preparations made by fire, we ought to prefer it to all others in the preparation of a perfectly neutral antimonial ſoluble tartar. For this purpoſe, we muſt mix together equal parts of cream of tartar and of porphyriſed glaſs of antimony, or rather a larger quantity of the latter ingredient. This mixture is to be thrown gradually into boiling water; and the boiling muſt be continued gently, till there is no longer any efferveſcence, and till the cream of tartar be entirely ſaturated. The liquor is to be filtrated; and upon the filter we may obſerve a certain quantity of ſulphureous matter, together with ſome undiſſolved part of the glaſs of antimony. When the filtrated liquor is cooled, fine cryſtals will be formed in it, which are a ſoluble tartar perfectly ſaturated with glaſs of antimony. The cryſtals of this ſalt have the form of triangular pyramids (a). They are tranſparent while they are

(a) The author probably means pyramids, the baſis of each of which is a triangle: for every pyramid muſt evidently have, at leaſt, four ſolid angles.

moiſt;

moiſt; but by expoſure to a dry air, they loſe a part of the water of their cryſtallization, and become opake and white.

As the perfect ſaturation of acids requires conſtantly a determinate quantity of any ſubſtance which they can diſſolve, we ſhould be certain, by ſaturating compleatly cream of tartar with glaſs of antimony, that the emetic tartar thus prepared would conſtantly contain the ſame proportion of emetic antimonial parts. The cryſtallizing and draining of neutral ſalts in general, is a good method for obtaining them in their moſt perfect ſtate: accordingly this ſalt ought to be firſt cryſtallized; but as by expoſure to the action of air it is apt to loſe ſome of the water of its cryſtallization, it ought, immediately after it has cryſtallized, to be well dried; and then it would remain unchanged. I have frequently adminiſtered emetic tartar thus prepared, and I have always obſerved, that it very well produces an emetic effect when taken from a grain to two and a half, or three, according to the conſtitution of the patients.

Authors who have given receipts for the preparation of emetic tartar, have differed, as we have obſerved, not only as to the kinds and proportions of the antimonial preparations which they direct to be boiled with cream of tartar, but alſo as to the duration of the boiling. Some of them require that the boiling ſhould laſt twelve hours, and others only a few inſtants, believing with Hoffman, that this ſalt is ſuſceptible of decompoſition and of loſing its emetic quality by a long continued boiling. Mr. Beaumé has determined this matter by well-conducted experiments, which ſhew that emetic tartar, like other metallic ſalts, is capable of being decompoſed by other metals to which its acid has a ſtronger affinity than the metallic baſis, and that iron particularly is capable of producing this effect upon emetic tartar; ſo that if it be boiled a long time in an iron veſſel, it is actually decompoſed, and the liquor is gradually changed into a tartariſed tincture of Mars. But Mr. Beaumé alſo found that emetic tartar may be boiled during any length of time in veſſels made of ſilver or of glaſs, without being decompoſed.

The reſults of theſe experiments of Mr. Beaumé are, 1. That any veſſels ought not to be employed in the preparation of emetic tartar; that eſpecially iron, and even copper, ought to be avoided, for this latter metal is found alſo to act a little upon emetic tartar; and that veſſels of ſilver or of glaſs ought to be uſed. 2. That as the intention of the operation is to ſaturate perfectly the cream of tartar, the boiling muſt be continued till this ſaturation be effected, which requires a long time when the glaſs of antimony is groſly pounded, but a much ſhorter time when it is well porphyriſed, as Mr. Beaumé practiſes.

We muſt acknowledge that emetic tartar, prepared by thus ſaturating completely the acid of tartar with glaſs of antimony, muſt be infinitely more uniform in its effects, than what is obtained by any of the other proceſſes hitherto practiſed. Nevertheleſs, when we reflect on the nature of the glaſs of antimony, we cannot affirm that this emetic preparation, notwithſtanding its perfect ſaturation, muſt always be of equal ſtrength. Glaſs of antimony is made by fuſing the grey calx of antimony, calcined to a certain degree. We know alſo, that if it be too little calcined, we ſhall obtain an opake matter, that reſembles the liver more than the glaſs; but that if it be too much calcined, it cannot be vitrified, nor even fuſed, by the moſt intenſe heat. But

between

between the degree of calcination which is ſufficient to give an opake fuſed matter, and the degree when it begins to be unfuſible, there are many intermediate degrees of calcination, all of which are ſufficient to produce glaſſes of antimony; but theſe glaſſes differ in degree of tranſparency, intenſity of color, and fuſibility, according as the calcination has been more or leſs compleat. We cannot doubt that different glaſſes of antimony muſt be more or leſs emetic, and that perhaps different quantities of theſe glaſſes are required for the perfect ſaturation of the acid of tartar. Beſides, we are not only ignorant of the degree of calcination which renders the glaſs moſt emetic; but alſo, if we did know it, we have no certain method of attaining it preciſely.

Hence, we are not certain that emetic tartar, prepared by ſaturating tartar with glaſs of antimony, has always an uniform and conſtant emetic power. Theſe conſiderations have determined me to ſearch, among the ſeveral preparations of antimony, for one which ſhould have the ſame advantages that glaſs of antimony has, of being convertible into a neutral ſalt by means of tartar, without the inconveniences of its uncertain degrees of emetic ſtrength; and I have found that the *powder of Algaroth*, or *mercury of life*, is capable of anſwering theſe intentions.

This preparation, which was formerly employed as an emetic, has been juſtly rejected with the other antimonials that have not a ſaline quality, becauſe it has the ſame inconveniencies as theſe have. It occaſioned accidents ſo terrible, that ſome phyſicians have affirmed, that it ought with more propriety to be called the *mercury of death* than the *mercury of life*. But theſe fatal effects do not prevent the poſſibility of rendering it a good remedy by a proper preparation; in the ſame manner as glaſs of antimony, which given ſingly produced much miſchief, has ſaved many lives ſince it was converted by its union with tartar into a moſt efficacious remedy.

Two cauſes concur in rendering the powder of Algaroth a violent and uncertain remedy. The firſt is common to it with glaſs of antimony, and with all the other antimonial preparations that are not ſaline; and is, its want of ſolubility in water, for the reaſons that we have aſſigned. The ſecond cauſe of the violent and uncertain effects of powder of Algaroth is, that a certain quantity of marine acid remains united with it, and communicates to it a certain degree of cauſtic quality. But both theſe cauſes of the bad effects of this preparation may be eaſily and certainly removed. For, by waſhing it with a little fixed alkali, all the acid may be ſeparated. And I have found from experiments, that the powder thus waſhed is altogether ſoluble by cream of tartar, and of being thereby convertible into a ſoluble emetic tartar, perfectly neutral; for which purpoſe, nothing more is required than to boil it, and ſaturate it with cream of tartar, and to treat it in the manner above directed for the preparation of emetic tartar with glaſs of antimony. We may eaſily perceive that powder of Algaroth thus prepared is a calx of antimony conſtantly of the ſame degree of emetic ſtrength. It is emetic, becauſe the regulus of antimony firſt diſſolved by marine acid, and afterwards ſeparated from that acid, retains the quantity of phlogiſton that is neceſſary to give an emetic quality to the calx of antimony: but the quantity of phlogiſton which it retains, and therefore its emetic power, muſt always be the ſame: for the marine acid of the

the corrosive sublimate, which afterwards becomes the acid of the butter of antimony, is always the same in quantity, and in its degree of concentration and of activity: consequently the calx of antimony separated from it must always contain an equal quantity of phlogiston; and is therefore much preferable to glass of antimony, which contains sometimes more and sometimes less phlogiston.

By substituting therefore powder of Algaroth to glass of antimony, and by treating it in the manner above-mentioned, we may obtain the most uniform and certain emetic tartar that can be prepared: physicians, who must be sensible of the advantage of such a remedy, need not be anxious concerning its degree of strength. If it were once known, they would have occasion only to attend to the sensibility or irritability of the constitutions of their patients. *See the articles* ANTIMONY, POWDER *of* ALGAROTH, GLASS *of* ANTIMONY, *and also all the other preparations of antimony.*

DCLXXX. TARTAR (VITRIOLATED). Vitriolated tartar is a neutral salt composed of vitriolic acid saturated with the fixed alkali of tartar, or with any other very pure vegetable fixed alkali.

This salt is prepared by pouring vitriolic acid into a solution of vegetable alkali, till no more effervescence appears, or till the liquor becomes perfectly neutral, which may be known by the ordinary trial of syrup of violets. From this liquor, filtrated and evaporated, small crystalls are obtained, each of which has many sides, sometimes more and sometimes fewer; for the crystallization of this salt varies much in this respect. It is, in general, one of those salts, the form of whose crystals is the least constant. The greatest number of the crystals of this salt appear to have been cubes, the angles of which have been cut off.

Vitriolated tartar is one of the salts which crystallize better by evaporation than by cold. It requires a large quantity of water to dissolve it. According to Mr. Spielman's experiments, thirty grains only of this salt are soluble in an ounce of water with a heat marked by ten degrees above o in the scale of Mr. Reaumur's thermometer. Its taste is moderately saline, and somewhat disagreeable, but not acrid nor sharp. It decrepitates, when heated suddenly and strongly. It contains a small quantity only of the water of crystallization, by means of which it cannot be liquefied; neither can it be fused but by a very intense heat.

As vitriolic acid has a greater affinity with the fixed alkaline basis of the vitriolated tartar than with any other substance, excepting phlogiston, and as this alkali has a stronger affinity with this than with any other acids, hence vitriolated tartar cannot be decomposed but by means of the inflammable principle, as in the process for making artificial sulphur. Mr. Beaumé has indeed discovered that vitriolated tartar may be decomposed in the humid way, by nitrous acid alone, which disengages the vitriolic acid, and forms nitre with its alkali. But if we examine well all the circumstances of this phenomenon, we shall find that this is no exception to the general rules concerning affinities, and that phlogiston is the principal agent in this singular decomposition, as Mr. Beaume has shewn in the explication that he has given of it. *(d)*

(*d*) Vitriolated tartar may be decomposed by nitrous acid in the following manner, according to Mr. Beaumé. Equal parts of vitriolated tartar and nitrous acid are put into a

Vitriolated tartar may also be decomposed by means of a double affinity, when it is mixed with solutions of certain metals in acids. But as by phlogiston only metals are dissolved in acids, we need not doubt that this principle has also some influence in these decompositions.

Since vitriolic acid has a greater affinity than any other acid with fixed alkali, we may therefore make vitriolated tartar by applying that acid to any neutral salt composed of an acid and a fixed alkali, as in the decomposition of nitre; and since fixed alkali has a greater affinity with vitriolic acid than any other substance, vitriolated tartar may be therefore made by applying a fixed alkali to any vitriolic neutral salt, the basis of which is not fixed alkali. Accordingly, all vitriolic salts with bases of volatile alkali, of calcareous, argillaceous, or metallic earths, may be decomposed by fixed alkalis; and the compound formed by these decompositions will always be a vitriolated tartar, consisting of the fixed alkali employed in the operation, and of the vitriolic acid of the decomposed neutral salt. Hence we may perceive, that vitriolated tartar is made in many chemical operations.

Before the theory of these operations was understood, and before the fixed vegetable alkali was known to be the same from whatever vegetable it was obtained, the several vitriolated tartars formed in different operations, and with the fixed alkalis obtained from different vegetables, were believed to be different kinds of salts, and were distinguished by different names; as the *sal de duobus*, *sal polychrest of Glaser*, *arcanum duplicatum*. But we now consider all these salts as the same vitriolated tartar, with which the other names are synonimous.

This salt is not of any use in the arts, and is but little used in chemistry. It is principally employed in medicine. Like the other neutral salts with bases of fixed alkali, it is aperitive in small doses, as a gros [72 grains]; and it is laxative, when taken from six gros to twelve. The vitriolated tartar which is prepared by decomposing nitre with vitriolic acid, called *sal de duobus*, has been much celebrated as a remedy against the effects proceeding from an extravasation of a milky humor, for which disease it has been considered as the best resolvent and evacuant. Nevertheless, as Mr. Baron well observes in his Notes on Lemery, no reason can be given for preferring this salt to other neutral salts. On the contrary, as it is one of those which are most perfectly saturated, its action and qualities must be less effectual than most of these. *See the articles* Acid (Vitriolic); Alkali (Fixed Vegetable); Crystallization; *and* Salt.

DCLXXXI. TERRA FOLIATA TARTARI; Foliated Earth *of* Tartar. This name has been given improperly, and merely for the

a matrass, and heated till the salt be dissolved. From the liquor, when cold, true crystals of nitre may be obtained. Mr. Beaumé believes that this decomposition is effected by means of the greater affinity of the nitrous than of the vitriolic acid to the phlogiston, which, he supposes, enters into the composition of the vitriolated tartar: and he thinks that the reason why this decomposition does not happen in the dry way or by fusion, as well as in the humid way or by cold solution, is, that the nitrous acid is in the former case dissipated by the action of the fire. This singular fact, which seems to contradict a general opinion, namely, that vitriolic acid is more disposed than nitrous acid to unite with fixed alkali, is also confirmed by the intelligent and accurate Mr. Margraaf, who further affirms, that in the same manner of treatment, vitriolated tartar, Glauber's salt, and nitre, may be decomposed by marine acid. As marine acid is certainly not more disposed to unite with phlogiston than nitrous and vitriolic acids are, Mr. Beaumé's explanation of this singular decomposition does not seem to be satisfactory.

the ſake of ſome earthy appearance. to a *neutral acetous ſalt with baſis of vegetable fixed alkali*, or to a combination of the acid of vinegar, ſaturated with the alkali of tartar or of other vegetable matters. This ſalt has alſo been called *regenerated tartar*, altho' it really be very different from true tartar, but only becauſe the alkali of tartar is united with an acid, which in ſome reſpects is ſimilar to the acid of tartar, but in others is very different, as may be ſeen at the articles TARTAR *and* VINEGAR.

The terra foliata is made, according to moſt diſpenſatories, by pouring upon a quantity of alkaline ſalt of tartar, in a glaſs-cucurbit, a ſufficient quantity of good diſtilled vinegar, at different times, to ſaturate all the alkali, or even a little more than is neceſſary for that purpoſe, and till the effervescence entirely ceaſes. This ſaturated liquor is to be filtrated, and evaporated to dryneſs, with a gentle heat. The dry ſalt thus obtained is to be diſſolved in ſpirit of wine, and the ſolution is to be again evaporated to dryneſs; by which means a ſalt is obtained more or leſs white, of a ſilky appearance, and compoſed of ſmall ſcales or leaves, from which it has been called *foliated*. When the ſalt is dried, and while it is yet hot, it muſt be ſhut up in a well cloſed bottle, becauſe it quickly becomes moiſt by expoſure to air.

When diſtilled vinegar is poured upon ſalt of tartar, little or no effervescence is made at firſt; but afterwards, when more vinegar is added, the effervescence becomes ſo conſiderable, that ſome of the liquor will flow over the veſſel, if care be not taken. This effervescence is produced by a large quantity of air that is diſengaged during the ſaturation. Accordingly the vapor extricated during the effervescence is very *aerial*, and ſo pungent, that if it be confined ſome time in a cloſe veſſel, and then ſet at liberty, it is as irritating and ſuffocating as volatile alkali, or volatile ſulphureous acid, although it be really different from either of theſe: for this vapor is nothing but aerial water ſimilar to the *gas* of ſpirituous mineral waters. *(e)*

When the ſaturation is advanced to a certain degree, the effervescence diminiſhes, and even ceaſes entirely, although the ſaturation be not yet compleated; the reaſon of which is, that the laſt portions of acid and of alkali do not very readily combine. The combination may be facilitated by frequently agitating the liquor, by which means the effervescence may be again renewed. When the liquor cannot by agitation be made to effervesce more, it may be then allowed to ſtand during ſome time, as Mr. Beaume practiſes. This chemiſt, and very excellent obſerver, has remarked, that the mixture depoſites a certain quantity of earthy matter proceeding from the fixed alkali, and which muſt be neceſſarily ſeparated by filtration, to obtain a very white foliated earth of tartar. He has

(*e*) The vapor which cauſes the effervescence in the preparation of this ſalt is the fixable air that is diſengaged from all mild alkaline ſubſtances by means of any acid; and the humid part of this vapor is nothing more than ſome particles of the effervescing liquor, which are forcibly thrown upwards by the riſing air, and which form a ſmall jet or ſhower above the ſurface of the effervescing liquor. *See* AIR (FIXABLE). The reaſon that this effervescence does not begin immediately upon pouring on the vinegar, is, that a part of the alkaline ſalt employed is generally cauſtic, or deprived of its fixable air, which part unites with the acid preferably to the mild part of the alkali, and abſorbs any air that is extricated from this latter part: and therefore till all the cauſtic part of the alkali be nearly ſaturated, little or no effervescence can happen.

alſo obſerved, that when the alkali employed is very pure, and free from any mixture of neutral ſalts, the ſaline matter produced by the proceſs has no foliated or cryſtallized appearance.

We have already remarked, that foliated earth of tartar is a deliqueſcent ſalt. This quality proceeds from the weakneſs of the union of the acid with the alkali; the cauſe of which ſlight union is, that ſome oily and ſpirituous principles are united with the acid in vinegar. The taſte of the foliated earth is ſharp, pungent, almoſt a little cauſtic, and partaking at the ſame time of the taſte of vinegar and that of fixed alkali. This ſalt is one of thoſe that are ſoluble in ſpirit of wine. It may be decompoſed merely by the action of fire; and from it, as from any other acetous ſalt, may be obtained by diſtillation, a radical vinegar, very penetrating and very concentrated.

Foliated earth of tartar is little uſed, but in medicine. It is conſidered as a powerful reſolvent and aperitive; and it probably poſſeſſes theſe qualities, merely as it retains ſome of the action of the acid and of the alkali, of which it is compoſed. Its doſe is from fifteen or twenty to thirty-ſix grains, or even more, when no irritation is apprehended. *See the articles* ALKALI (FIXED); SALT; SALTS (NEUTRAL); *and* VINEGAR.

DCLXXXII. TERRA JAPONICA. *See* JAPONIC EARTH.

DCLXXXIII. TEST, *and* TESTING. (*f*)

DCLXXXIV. TIN. Tin is a metal, the color of which reſembles that of ſilver, but is darker and leſs white. It is ſofter, leſs elaſtic, and leſs ſonorous than any other metal, excepting lead.

When it is bent backwards and forwards, it occaſions a crackling ſound, as if it was torn aſunder.

Tin has, like other imperfect metals, a ſmell and a taſte.

It is much leſs ductile than ſome harder metals; although it may be beat into very thin leaves.

The tenacity of the parts of tin is not very conſiderable, ſince a wire of this metal, the diameter of which is $\frac{1}{10}$ of an inch, can ſupport a weight of $49\frac{1}{2}$ pounds only.

It is the lighteſt of all metals, as it loſes only $\frac{1}{7}$th part of its weight, when immerſed in water. It is very fuſible, and requires for this purpoſe a heat much leſs than is ſufficient to make it red-hot.

With the heat neceſſary for its fuſion it may alſo be calcined, or at leaſt deprived of ſo much of its phlogiſton that it appears in form of a grey calx, which cannot be reduced entirely to tin without the addition of ſome inflammable matter.

Workmen call this imperfect calx of tin, *aſhes of tin*; and thoſe who travel in the country, caſting tin ſpoons, call it *droſs of tin*. This they carefully ſkim off, pretending thereby to purify their tin. But they preſerve this pretended droſs, and reduce it to tin by melting it with ſome pitch.

Theſe aſhes of tin, like other calxes of metals, may be further deprived of phlogiſton, by a calcination continued with a more intenſe fire, by which means

(*f*) TEST *and* TESTING. A teſt is a large kind of cupel uſed in operations for refining large quantities of gold and ſilver by means of lead; and the operation is called *teſting*. *See* CUPEL; CUPELLATION, *and* REFINING.

it

it becomes more and more white, hard and refractory. It is then called *putty*, and is used in the arts for polishing glass and other hard bodies.

Calx of tin, very white and well calcined, is a very refractory substance. Its beautiful whiteness and refractory quality render it capable of forming, together with some fusible and vitrifiable matters, a white enamel, which is used as a white glazing or covering for delf-ware. *See* DELF-WARE.

The most ordinary method of preparing this putty, is by mixing together lead and tin, and exposing this mixture to a strong heat. These two metals have been found to be more easily calcinable when mixed than when single. By adding to the calx thus obtained some sand and vitrifiable salts, and by fusing the mixture, a very beautiful white enamel may be made: for lead does not, like tin, lose its fusible quality by calcination.

I have exposed very pure tin, singly, to a fire as strong as that of a glass-house, during two hours, under a muffle, in an uncovered test; and having then examined it, I found it covered with an exceedingly white calx, which appeared to have formed a vegetation; and under this matter, a reddish calx, and a transparent hyacinthine glass; and lastly, at the bottom, a piece of tin unaltered. This experiment was several times repeated with the same success.

Nitre mixed with tin may be inflamed, and it hastens considerably the calcination of this, as it does of other imperfect metals. The vapors which rise during the several calcinations of this metal have generally an alliaceous or arsenical smell; because tin generally contains some arsenic, as Mr. Margraaf has observed.

Although tin be one of the most calcinable metals by means of fire, it is much less apt to rust by the combined action of air and water, than iron and copper. Its surface, when it is clean and shining, loses indeed its lustre, and tarnishes quickly by exposure to air, but the slight kind of rust which is there formed remains thin and superficial, and does not advance so deeply into the substance of the metal as the rust of iron and of copper generally does. Hence tin is advantageously employed to cover many utensils made of these metals. *See* TINNING.

Every acid is capable of attacking or dissolving tin.

Vitriolic acid requires to be assisted by a certain degree of heat to dissolve tin efficaciously. I have observed, that during this solution sulphureous vapors are raised; and I have even separated some black particles, which I have found to be true inflammable sulphur. The production or extraction of this sulphur requires a particular examination. *See* SULPHUR.

Nitrous acid attacks tin with very great violence, especially when the metal is much divided. But when the acid is very pure, it rather corrodes and calcines than dissolves tin. As the phlogiston of this metal is not very strictly engaged, the nitrous acid chiefly attacks it by means of this principle, which it seizes, and separates from the tin, that is thus reduced to an unsoluble white earth, or calx, deposited at the bottom of the acid. This calx of tin made by nitrous acid appears to be as perfectly dephlogisticated, as that which had been exposed during a long time to fire. I have attempted unsuccessfully to reduce it to its metallic state. This calx makes a very good white enamel.

The

The acid of common ſalt diſſolves tin perfectly well by help of heat. I have obſerved, that when I put a conſiderable quantity of fine granulated tin into a matraſs, and poured ſome ſmoking, and conſequently colored, ſpirit of ſalt upon it, that the acid quickly ceaſed to ſmoke, and loſt its color; that it attacked the tin with a ſenſible but moderate effervеſcence, and became ſaturated with it. This acid diſſolved more than half its weight of tin. The vapors which roſe during the ſolution had a diſagreeable arſenical ſmell; and the ſolution when ſaturated was clear and colorleſs as water. Having kept the ſolution in a bottle, I obſerved that, during the winter, it almoſt all cryſtallized, and that the cryſtals became fluid during ſummer. Some years afterwards a white ſediment was formed in this ſolution.

Tin has a greater affinity with marine acid than ſome other metallic ſubſtances which have alſo much affinity with this acid; for it ſeparates the marine acid from luna cornea, from corroſive ſublimate, and from butter of antimony. When tin is mixed, eſpecially with corroſive ſublimate, it decompoſes this ſalt, even without heat; and the mixture produced becomes moiſt by expoſure to air. If it be diſtilled before it has imbibed much moiſture, a very ſmoking ſpirit of ſalt, called *ſmoking ſpirit of Libavius*, is obtained. *See* SPIRIT (SMOKING) *of* LIBAVIUS.

This acid retains much tin diſſolved, ſome of which it raiſes along with it in diſtillation, as it does ſeveral other metallic matters. Accordingly, in this diſtillation, a concrete, ſaline, metallic matter is ſublimed, that may be called *butter of tin*: which name has been given by ſome chemiſts to the ſmoking ſpirit.

From the detail we have given of the ſolutions of tin by nitrous and marine acids we may perceive, that the former acid deprives it of all its inflammable principle, but has no action upon its dephlogiſticated earth; and that the effects of the marine acid upon this metal are quite the reverſe. Accordingly, when theſe two acids are united together, forming an aqua regia, they compoſe a menſtruum, which acts very efficaciouſly upon tin, on account of the activity of the nitrous acid, but which does not deſtroy the metal, as nitrous acid ſingly does, becauſe the action of this acid is moderated by the marine acid: hence, the more nitrous acid is contained in aqua regia, the more ſimilar are its effects upon tin to thoſe produced by nitrous acid alone; and reciprocally with regard to marine acid.

A good ſolution may be made of tin in aqua regia, if attention be given to the following particulars. A ſmall quantity only of tin ought to be put into the acid, and no more added till the firſt piece be entirely diſſolved; becauſe when much tin is added at once, the heat occaſioned by the ſolution encreaſes the activity of the ſolvent ſo much, that the tin is as much calcined and precipitated as if pure nitrous acid had been employed; but when the tin is added gradually, and the heat is thus reſtrained, the aqua regia may be ſo charged with this metal, that it ſhall be thick and viſcid, like a a liquid tranſparent reſin. The ſolution thus charged has a yellow-reddiſh color

We may obſerve, that in this ſolution there is a conſiderable quantity of tin upon which the nitrous acid of the aqua regia has not exhauſted all its action, although this menſtruum ſeems to be more than ſaturated; for I have obſerved, that when this liquor is heated, an effervеſcence happens entirely ſimilar to that

which

which is occasioned during the solution of metals by acids. This effervescence lasts till the parts of the tin which were only half dissolved have been redissolved a second time; after which the solution is found to have lost its color. Sometimes this solution becomes quite fixed or solid when it cools, and appears like a firm jelly, and transparent as crystal.

All the solutions of tin are acid and corrosive; and may be decomposed by being diluted with much water; in which case, the tin is copiously precipitated in form of a white calx.

When a solution of tin is mixed with a saturated solution of gold, and when the mixture is diluted with a large quantity of water, a purple precipitate is formed, called *purple powder of Cassius. See that word.* This powder is employed for painting on enamels and on porcelain.

The solution of tin in aqua regia, added to the tinctures of cochineal, of gum lac, and of some other red tinctures, heightens the color of these, and changes it from a crimson or purple to a vivid reddish-yellow or fire-colored scarlet. Dyers call this solution of tin, with which they give a scarlet tinge, *the composition.* We may observe, that this color succeeds only with wool and other animal matters. Attempts have been made, but without success, to give this color to thread, to cotton, or even to silk, although this latter substance has many properties of animal matters.

I have also observed, that the larger quantity of nitrous acid is contained in the aqua regia, which dissolves the tin, the nearer does the red color communicated to cochineal approach to the vivid yellow; so that the solution of tin made with marine acid alone, or with vitriolic acid, do only give to red tinctures a crimson color, as alum does. *See* DYING.

Vegetable acids, as vinegar and cream of tartar, are also capable of dissolving tin: but the properties of these solutions have not yet been well examined.

Tin, according to Mr. Geoffroy's table of affinities, has a stronger affinity with the acid of common salt than regulus of antimony, copper, silver, and mercury; because the combinations of this acid with these metals are decomposed by tin, which precipitates them, and unites with the acid.

Sulphur may be united with tin by fusion, and forms with it a brittle mass, more difficultly fusible than pure tin. Sulphur has in this respect the same effect upon tin as upon lead. The allay of sulphur lessens the fusibility of these very fusible metals, while it encreases the fusibility of other difficultly fusible metals, as of iron and copper.

Tin may be allayed with all metals by fusion, and in all proportions; but it absolutely destroys their ductility. A remarkable circumstance is, that the most ductile metals, as gold and silver, are those the ductility of which is most injured by tin. The vapor of a single grain of tin is capable of rendering a considerable quantity of gold brittle. The ductility of copper is less injured by tin than that of other metals, although it is considerably injured. A singular circumstance concerning this allay is, that tin, although a very soft metal and not at all sonorous, augments considerably the stiffness, the hardness, and the sonorousness of copper, as we see in *bell-metal.*

The allay, or amalgam of tin with mercury, is employed to cover one of the surfaces of looking-glasses, by which they are rendered capable of reflecting the

rays

rays of light, and of forming mirrors. This covering of tin and mercury, which is applied upon glaſſes, is called *tinning*.

Tin, allayed with an equal quantity of lead, forms the ſolder uſed by plumbers.

According to Mr. Gellert's table, the affinities of tin are, iron, copper, ſilver, and gold. *See, for the allays of tin, the words* ALLAY, AMALGAM, *and* BRONZE.

Tin is not much uſed in medicine, and for good reaſons: for we find, from a long Diſſertation by Mr. Margraaf upon this metal, that tin generally contains more or leſs of an arſenical matter, which probably proceeds from the ores of tin, as all theſe contain arſenic. *See* ORES, *and* SMELTING *of* ORES. Mr. Margraaf diſcovered this arſenical part of tin chiefly in the humid way, and by ſolution in acids. The white calx of this metal is commonly employed in the preparation of the *antihectic of Poterius*, and of the *lilly of Paracelſus*: but this calx is unſoluble and ineffectual; beſides, it appears to furniſh no part of the lilly.

Tin is very extenſively uſeful in many arts, as we may judge from what has been ſaid of the different preparations of this metal.

DCLXXXV. TINNING *of* COPPER, *and of* IRON. Tinning is an operation by which a very thin layer of tin is applied to the ſurface of ſome metals, and eſpecially of copper and of iron. The methods of tinning theſe two metals are different. Copper is tinned after it has been formed into utenſils, and by the copper-ſmiths who form theſe utenſils. The tinning of iron is performed upon thin plates of iron, in particular manufactories in France, in Germany, and in ſome other places. Workmen, called *tin-ſmiths*, do only form theſe plates, which are brought ready made from their proper manufactories, into the various utenſils required.

The ſeveral operations for tinning of copper and iron are founded, firſt, on the facility with which tin unites with theſe metals, which is ſo great, that when either of theſe metals are tinned, the tin only requires to be melted, and the others on which it is to be applied do not. Nevertheleſs, the tin incorporates with theſe metals, diſſolves in ſome meaſure their ſurface, and forms a kind of allay, at leaſt when the tinning is well performed.

Secondly, the foundation of all the parts of the operation uſed to make the tinning ſucceed is, that metals cannot perfectly unite with each other but when they are in a metallic ſtate, and that they cannot unite with any earthy matter, not even with their own earths or calxes.

Hence, the whole art of tinning conſiſts in applying melted tin, the ſurface of which ſhall be very clean, metallic, and not covered with any aſhes or calx of tin, to the ſurface of iron or of copper, which muſt alſo be very clean, and free from all ruſt or calx.

To attain theſe purpoſes, the following method is uſed. As the ſurface of copper is continually altered merely by the action of air, the workmen, before the tinning of any veſſel, ſcrape its ſurface with a ſteel inſtrument till it be clean and bright: then they place the veſſel upon kindled coals, and heat it to a certain degree: as ſoon as it is hot, they rub it with pitch; and then apply the melted tin, which they ſpread upon the ſurface of the copper by

by means of hards. Pure tin is ſeldom uſed for this purpoſe; but generally two parts of tin are allayed with one part of lead.

The pitch uſed in this operation is quite neceſſary, becauſe the degree of heat given to the copper is ſufficient to calcine its ſurface in ſome meaſure; and this alteration, however ſlight, would prevent the perfect adheſion of the tin, unleſs, by means of the pitch, the phlogiſton was reſtored to it at the very inſtant of the application of the tin. This pitch prevents alſo the ſlight calcination which would happen on the ſurface of the tin, or revives the ſmall particles of calx which are formed during the operation.

When plates of iron are to be tinned, they muſt be perfectly well cleanſed, which is done by ſcouring them with ſand, and ſteeping them ſome time in acid liquors: then they are to be wiped, and dried quickly and perfectly. Laſtly, they are to be plunged vertically into a veſſel containing melted tin, the ſurface of which is covered with fat and pitch. Theſe fat ſubſtances covering the ſurface of the tin, ſupply it continually with phlogiſton, prevent its calcination, by which its adheſion to the iron would be impeded, and alſo render the ſurface of the iron, while it paſſes through them, fitter to receive the tin. By thus plunging plates of iron into melted tin, they are covered over with this metal, or are tinned.

Sal ammoniac is alſo uſed ſucceſsfully in the tinning of iron and of copper, and always for the ſame reaſon. The acid of this ſalt perfectly cleans the ſurface of the metals to be tinned, and alſo the oily matter contained in ſal ammoniac furniſhes the phlogiſton that is neceſſary in this operation. Thus, by heating theſe metals to a certain degree, and rubbing them with ſal ammoniac, the tin may be applied immediately afterwards.

The advantages received from tinning are very conſiderable. As tin is a ſoft and fuſible metal, veſſels formed of it alone would not have ſufficient ſtrength and hardneſs to keep their ſhape in common uſe, and would alſo be liable to be melted with a ſmall heat: but when it is applied to the ſurface of hard and difficultly fuſible metals, as copper and iron, many veſſels may be fabricated, which have the advantage of being preſerved, by means of the tin, from ruſt, to which the copper and iron are very ſubject. It has been, nevertheleſs, juſtly alledged, that copper veſſels are not perfectly prevented from ruſt or verdigriſe by tinning; and this fault is ſo much more important, as tinned copper veſſels are generally uſed in the preparation of victuals. Theſe veſſels therefore, even when tinned, ought not to be employed for this purpoſe; eſpecially as tin itſelf is ſuſpected of being hurtful to health, ſince Mr. Margraaf diſcovered that arſenic is contained in almoſt all tin; and alſo becauſe lead, a moſt hurtful metal, is uſed in tinning. Nevertheleſs, tinned copper veſſels may be uſed for many other purpoſes. Beſides, the tinning of copper and iron veſſels may be improved, by attending to the fundamental principles of this art delivered in the preſent article.

DCLXXXVI. TINNING *of* LOOKING-GLASSES. This operation conſiſts in applying an amalgam of tin and mercury upon one of the ſurfaces of looking-glaſſes, by which they are rendered much more capable of reflecting the rays of light, and conſequently of repreſenting, in a clear and lively manner, the images of objects.

This effect of the tinning of looking-glasses is founded on the superior opacity, and consequently on the superior reflective power of metallic to all other substances.

Glasses to be tinned are placed upon tables, in a perfectly horizontal or level situation. The surface, previously well cleaned, is to be covered with tin-leaves, which also must be very clean. Upon these is poured a sufficient quantity of mercury to cover the whole surface, and it is allowed to rest some time, that it may amalgamate perfectly with the tin-leaves: then a small degree of inclination is given to the glass, that the superfluous mercury may run off; which inclination must be gradually encreased till the glass be at last brought to a vertical situation, by which means no more mercury remains than is really amalgamated with the tin. As the surface of the glass is exceedingly smooth and well polished, the amalgam is in very perfect contact with it, and therefore firmly adheres to it.

The success of this operation depends much on the cleanness of the surface of the glass; for the least dirt or dust interposed betwixt the amalgam and the surface of the glass would absolutely prevent the adhesion of contact between these two bodies.

Since vitrified matters, as glasses are, cannot unite intimately with metallic substances, the adhesion of the amalgam upon the glasses is not so strong as that of metals upon metals; as in the tinning of copper and of iron, in which there is a solution, a penetration, and an intimate union of the tin with the surface of the tinned metal: but in the tinning of looking-glasses, there is only the adhesion of contact, or of a perfect juxtaposition, which may take place between any bodies, however heterogeneous, by the application of their polished surfaces. Accordingly, this metallic covering may very easily be taken off, and ought to be preserved from moisture, and from any kind of rubbing, however slight. For which reason, the superfluous mercury must be made to run off very gently and slowly, otherwise all the amalgam might fall off by its weight.

DCLXXXVII. TINCAL. (*g*)

DCLXXXVIII. TINCTURE. By this name are distinguished, in chemistry and pharmacy, all spirituous liquors that are colored by being digested upon different substances. These are, properly speaking, infusions in ardent spirits.

Many chemical preparations are called *tinctures*. We shall treat of some of the chief of these.

DCLXXXIX. TINCTURE (ALKALINE). *See* TINCTURE *of* SALT *of* TARTAR.

DCXC. TINCTURE *of* ANTIMONY. This tincture is made, according to the Paris Dispensatory, in the following manner: Let a mixture of one part of crude antimony with two parts of the alka-

(*g*) TINCAL. Borax, in the crude state in which it is brought from India, and before it is refined, is called tincal. It consists of small crystals, of a yellowish color, and it has a greasy or unctuous touch. According to Mr. Cadet, it contains a larger quantity of the peculiar vitrescible earth of borax, than the refined salt commonly sold does. *See* BORAX, *and* SALT (SEDATIVE).

line salt of tartar, be fused in a covered crucible, and the fusion continued during an hour. The melted matter is to be poured out; and as soon as it has become solid, it is to be pulverised: while yet hot, it is to be put into a matrass; and upon this powder rectified spirit of wine is to be poured, to a height above the powder equal to the breadth of three fingers. This tincture is to be digested with a gentle heat during several days, by which it acquires a deep red color; and then it is to be decanted and preserved in a well-closed bottle.

In this fusion of crude antimony with fixed alkali, a liver of sulphur is formed, which dissolves the reguline part of antimony. It is consequently an antimoniated liver of sulphur, nearly of the same nature as that of which *kermes mineral* is made: but in the present operation this matter is not dissolved in water, but is digested in spirit of wine; which menstruum seems to dissolve a part of the whole matter, that is, a part of the liver of sulphur, and by means of it also some of the regulus of antimony; for this tincture acquires a red color, and produces nausea, according to Lemery, when taken internally. According to the same author, the dose of this tincture is from four drops to twenty, and is to be administered in some proper liquor.

The medicinal effects of this preparation may be very good, and analogous to those of kermes; but it is not much used. *See* KERMES (MINERAL).

This solubility of antimoniated liver of sulphur in spirit of wine is remarkable: but an explanation of all the appearances that occur in this and in several other operations, would require more particular researches than have yet been made.

DCXCI. TINCTURE *of* MARS. Iron, being a metal much employed in medicine, has been prepared in various manners for internal use. Amongst the principal of these are the following tinctures.

DCXCII. TINCTURE *of* MARS (LUDOVICUS's). This tincture is made, according to the Paris Dispensatory, in the following manner: Four ounces of martial vitriol calcined to whiteness are to be mixed with an equal quantity of cream of tartar, and this mixture is to be boiled in a pound and a half of water, till the whole has acquired the consistence of honey. This mass is to be put into a matrass, into which some rectified spirit of wine is to be poured to a height equal to the breadth of four fingers. After a digestion during some time in a sand-bath, the tincture is to be decanted, and fresh spirit of wine is to be poured on the residuum, and digested as before. These operations are to be continued as long as the spirit of wine acquires color: and, lastly, all these tinctures are to be mixed together and preserved for use.

The theory of this process is not well known; because all the circumstances have not been examined with sufficient attention. We see, indeed, that the cream of tartar ought to act upon the portion of the iron of the martial vitriol, which does not adhere very strongly to the vitriolic acid, or which is even quite disengaged from that acid by calcination; and that this combination of iron with cream of tartar may be soluble in spirit of wine, to which it may communicate color, and consequently may form the present tincture: but does not the cream of tartar act also upon the iron which is united with the vitriolic acid; and if it does not act, does the martial vitriol dissolve in spirit of wine?

If it does not dissolve in this spirit, when it is single and in its ordinary state, and charged with much iron, may it not become soluble either when it has deposited a part of its iron, or by means of the acid of tartar? These are questions which, I believe, have not been yet examined; but which must be ascertained, before we can know precisely the nature of this tincture of Mars. For its medicinal virtues, *see the article* Iron.

DCXCI. TINCTURE *of* MARS *of* MYNSICHT. This tincture is made by digesting the martial flowers of sal ammoniac with a sufficient quantity of rectified spirit of wine in a matrass.

Spirit of wine dissolves the salt formed by the union of iron with the acid of sal ammoniac; but as this spirit can also dissolve the sal ammoniac itself, it may be charged with a certain quantity of the latter salt in this operation: it is even very possible, that by means of this sal ammoniac, it dissolves a greater quantity of the martial salt than it would otherwise do; and reciprocally, that the martial salt puts it in a condition of dissolving a greater quantity of sal ammoniac; which effects are similar to those produced by treating in the same manner corrosive sublimate and sal ammoniac in spirit of wine: but I do not believe that any researches have been made to elucidate this subject. Chemists, who have given receipts for most of the medicinal preparations of the kind of which we now treat, made frequently capricious mixtures, the effects of which they did not know. These preparations have been consecrated by use, although little trouble has been taken to ascertain their nature: but now that chemistry, taken in its true and genuine spirit, has become a science as accurate and rigorous in some measure as geometry, all these ancient receipts ought to be scrupulously examined. We should then certainly reject many of these for their unfitness to produce the effects expected, and we should know better the virtues of those which should be judged worthy to be retained in use. Probably the tincture of Mars of Mynsicht possesses the medicinal qualities of iron dissolved by marine acid, and of sal ammoniac.

DCXCIII. TINCTURE *of* MARS (ALKALINE) *of* STAHL. This preparation, the knowledge of which Stahl has communicated to us, is a solution of iron in fixed alkali. Although this saline substance be capable of acting directly upon iron, and of dissolving it in some measure, this combination succeeds much better when the iron to be united with the alkali is previously divided by being dissolved in an acid, and especially in nitrous acid, as Stahl has shewn.

According to the process of this celebrated chemist, the iron ought to be previously dissolved in nitrous acid, and the solution ought to be as perfectly saturated as possible. This saturated solution is to be added at several different times to a strong solution of vegetable fixed alkali. Each time that the solution of iron is poured into the alkaline liquor, a kind of precipitate or coagulum of a deep red saffron color is instantly formed: but this precipitate disappears soon after, and dissolves entirely in the alkaline liquor, to which it communicates a deep-red yellowish color. More of the solution of iron is to be poured into the alkaline liquor, till the precipitate is no longer redissolved. Lastly, this solution, which is the martial alkaline tincture of Stahl, is to be filtrated.

We may easily conceive what passes in this process. The alkali, into which the combination of iron with nitrous acid is poured, decomposes at first this combination,

combination, by uniting with the acid, and precipitating the iron. But as there is much more alkali than is required to saturate the quantity of acid added, the uncombined portion of alkali finding the iron in a very divided state, attacks and dissolves it perfectly.

Iron is not the only metal that may be thus dissolved by an alkali. Almost every metal is more or less soluble by alkalis, as Mr. Margraaf has shewn. *See his Opuscules Chymiques, Diss.* III. This celebrated chemist found that not very pure alkalis, but alkalis phlogisticated by calcination with ox's blood and volatile alkali, were fit for this purpose.

This solution of iron in fixed alkali does not always succeed, and even sometimes fails, when all the circumstances directed by Stahl have been observed. I have remarked, and also Mr. Beaumé, that it succeeds much more constantly, and almost certainly, when a solution of iron not nearly saturated and very acid is employed; and when the solution has not the reddish-yellow color of rust that saturated solutions have, but is clear and limpid, or only slightly greenish. We were also induced to believe, that a similar excess of acid was favorable for redissolving other metallic precipitates from their acid menstruums by means of alkali; and even that without this excess, the operation cannot succeed. But Mr. Marges, an intelligent chemist, has shewn me a solution of iron much impregnated, and high-colored, the iron of which might be perfectly dissolved by fixed alkali, without heat; and which constantly formed the martial alkaline tincture, either by pouring the solution to the alkali, or the alkali to the solution; which proves that this phenomenon depends on the concurrence of several circumstances; as on the state of the iron in the nitrous acid, which is known to be very variable; on the greater or less phogistication of the alkali; and perhaps also on several other circumstances, which ought to be more fully examined, before we can form a judgment.

The martial alkaline tincture certainly contains an iron very much divided, in a saline and perfectly dissolved state, though it is not united to any acid; and as it also possesses a saponaceous alkaline character, it may be very useful in all cases where martial and anti-acid remedies are at the same time indicated: and these cases are very frequent, as practical physicians well know.

A very fine saffron of Mars may be separated from this solution, either by precipitating the iron by gradually saturating the alkali with any acid, or by a spontaneous deposition of a ferruginous sediment, which is slowly formed in this, in the same manner as in the acid solutions of iron. We shall only observe, that the iron which has been thus dissolved by an alkali is very soluble in acids; so that when it is to be precipitated by an acid, we must take care not to add a drop more than is necessary for the perfect saturation of the alkali, otherwise all the precipitate instantly disappears, and the liquor becomes clear and almost colorless. *See* ALKALI *and* IRON.

DCXCIV. TINCTURE *of* MARS (TARTARISED). This preparation, like the preceding, is called a tincture, although it contains nothing spirituous, but merely from its deep color. It is a solution of iron by the acid of tartar; and is a true *Martial soluble tartar*, as we shall see.

This combination is made, according to the Paris dispensatory, in the following manner. Six ounces of clean filings of iron, and a pound of powdered white

tartar

tartar are to be mixed together in an iron veſſel; the mixture is to be moiſtened with a ſufficient quantity of water to form it into a maſs, which muſt be left undiſturbed during 24 hours, that the acid of tartar may begin to act upon the iron. Then ſix Paris pints [12 pounds] of pure water are poured on the mixture, and boiled together during two hours. From time to time the mixture muſt be ſtirred during the boiling, and hot water is added to ſupply the place of that which is evaporated. The liquor is then to be left to ſettle, and to be filtrated and evaporated to the conſiſtence of a liquid ſyrup. Laſtly, an ounce of ſpirit of wine is to be added to it, to prevent the ſolution from becoming mouldy.

In this operation, the acid of tartar diſſolves the iron, becomes ſaturated, and forms with it a neutral ſalt, which is not only very ſoluble in water, but which is even very deliqueſcent: hence this ſalt cannot be cryſtalliſed, but is obtained in the ſtate of a liquor, or of an extract, ſometimes dry and ſometimes ſoft, according as it has been more or leſs evaporated. The color of this ſalt is red, or brown, and its taſte is the ſame as that of all ſalts the baſes of which are iron, though ſomewhat leſs auſtere and ſtyptic.

The union of the acid of tartar with iron is very weak and very ſuperficial in this combination; and hence this ſalt is very deliqueſcent. This deliqueſcence is ſurprizing, conſidering that, as we have remarked elſewhere, the two ſubſtances which compoſe it have little or no ſolubility in water. From this difficult ſolubility in water of the component parts of the tartariſed tincture we may conclude, that in whatever proportions theſe parts are mixed together, this tincture muſt always be a neutral ſalt, perfectly or nearly ſaturated: for if any portion of tartar be not combined with the iron, it will remain at the bottom of the veſſels, or upon the filter; and the ſame obſervation may be applied to the iron that is not combined with the tartar. Nevertheleſs, as pure tartar is ſoluble in water, and as conſequently a ſmall portion of it may remain unſaturated in the liquor, it would be proper, if this martial ſoluble tartar be required perfectly neutral, to add more filings of iron than are ſufficient to ſaturate all the acid; becauſe the ſuperabundant quantity could not remain in the ſolution, and becauſe by this method of employing a large quantity of filings, the operation may be much ſhortened; whereas it would be very long, if no more filings were employed than is required for the ſaturation of the tartar, and if at the ſame time all the tartar was required to be ſaturated.

The tartariſed tincture of Mars has the ſame medicinal qualities as the other ſaline and ſoluble preparations of iron; but it is, as we have ſaid, the leaſt ſtyptic. Accordingly, in caſes where martial preparations are indicated, and at the ſame time the ſtyptic quality of iron is apprehended, this is one of the beſt preparations of iron that can be preſcribed. It does not eſſentially differ from the infuſion of martial balls. *See* Iron, *and* Tartar.

DCXCV. TINCTURE *of* METALS, *or* LILLY *of* PARACELSUS. This preparation may be made by ſeveral proceſſes; but as they do not much differ, we ſhall here give the eaſieſt and readieſt.

Two parts of martial regulus of antimony, one part of fine tin, and one part of pure copper, are melted together in a crucible. The allay thus compounded

pounded is to be powdered, when cold, and mixed with thrice its weight of purified nitre. The mixture is to be thrown at different times into a red-hot crucible, where it detonates, and is exposed to a violent fire, till the metals be perfectly reduced to calxes. The matter is to be taken from the crucible while red-hot, and immediately thrown into a heated iron mortar, where it is quickly powdered. The powder is to be put, while yet hot, into a matrass, and upon it some rectified spirit of wine is to be poured to a height equal to the breadth of four fingers. The digestion is continued during some days, or till the spirit of wine has acquired a very deep yellowish-red color. The spirit is to be decanted and kept in a bottle; and is called the *Tincture of Metals*, or *Lilly of Paracelsus*.

From this name *Tincture of Metals*, we find that the spirit of wine was supposed to extract something from the metals on which it is digested in this process; perhaps its color gave rise to this opinion. Nevertheless, as Mr. Baron well observes in his Notes on Lemery, if we consider that the metallic matters are reduced almost to the state of pure earths by calcination, we shall be convinced that no part of them can be dissolved by the spirit of wine. Besides, Mr. Beaumé, having particularly examined this preparation, was convinced by experiments that no metallic matter can be separated from it. But although it contains no metallic matter, we do not say that it is ineffectual, or that it has no other qualities but those of the pure spirit of wine. On the contrary, we know that the nitre is alkalised in this operation; and that this alkali, which is capable of being rendered as caustic by metallic calxes, as it is by quicklime, acquires a power of acting singularly and effectually on spirit of wine, which it partly decomposes. This alkali either forms with the spirit of wine, or it separates from this spirit, an oil, with which it combines, and to which it gives color, and a very acrid taste. Hence the tincture of metals resembles much the *tincture of salt of tartar*, of which we shall afterwards treat, and like which it has a spirituous, saponaceous, acrid, and alkaline character. Accordingly, it is successfully used when the fibres and vessels require to be excited and animated; as in apoplexies, palsies, dropsies. For the same reason, it is capable of accelerating the motion of the blood, and of encreasing certain secretions and excretions, particularly sweat and urine. The dose of this tincture is from six or twelve drops to forty or even more, and it must be administered in some proper cordial.

DCXCVI. TINCTURE *of* GOLD. *See* GOLD (POTABLE).

DCXCVII. TINCTURE *of* SALT *of* TARTAR. This tincture is made by pouring some rectified spirit of wine to a height equal to the breadth of three or four fingers, into a heated matrass that contains some hot salt of tartar, which had been previously fused in a crucible and powdered. The matrass is to be closed, and the digestion is to be continued during several days with a gentle heat, or till the spirit of wine has acquired a fine reddish yellow color.

This preparation is essentially the same as the tincture of metals, as in both these, the fixed alkali acts upon and colors the spirit of wine; with this difference only, that as the alkali of tartar, in its ordinary state, is much less caustic than when it has been calcined with metallic calxes, it therefore acts less quickly

and

and powerfully in the tincture of salt of tartar than in the tincture of metals. Accordingly the former preparation is more deeply colored than the latter. But if in the preparation of the tincture of salt of tartar, an alkali previously rendered caustic by quicklime be employed, the tincture will be as red and active as the tincture of metals; and hence the medicinal qualities of these two tinctures are the same.

DCXCVIII. TINCTURES *of* VEGETABLE *and* ANIMAL SUBSTANCES. Many medicinal preparations are called tinctures, because they are made by digesting certain vegetable and animal substances in spirit of wine, to which they communicate different colors, according to their nature.

Some of these tinctures are made with one vegetable or animal substance only. These are called *simple tinctures*, and they are distinguished by the name of the vegetable or animal matter employed; such are the tinctures of myrrh, of aloes, of saffron, of castor, and many others.

Others contain a greater or less number of different vegetable and animal substances, which are digested in spirit of wine, according to the several receipts. These have the general name of *compound tinctures*, and are also distinguished by the names of their particular authors and qualities.

We shall not here enter into a detail of these several tinctures, because they are rather objects of pharmacy than of chemistry; but shall confine ourselves to the following general observations.

First, as vegetables and animals are composed of several principles which are not all soluble, or not equally soluble in spirit of wine, we cannot consider spirituous tinctures as complete extracts of the vegetable and animal substances employed in their preparation.

Secondly, the principles of these substances upon which spirit of wine can act, are volatile essential oils, and others of the same nature; resins, properly so called; any oils that are in a saponaceous state, and soluble in water by means of some saline matter; acids; and lastly, several kinds of neutral salts. And the principles which spirit of wine cannot dissolve directly are sweet oils and oily concretions that are not volatile nor saline; substances purely gelatinous and gummy; earthy matters not saline nor soluble in water; and lastly, many neutral salts, which are insoluble in spirit of wine, the various kinds of which have not yet been determined.

Thirdly, many of the vegetable and animal principles that are essentially unsoluble in spirit of wine, particularly gums, jellies, and neutral salts, are soluble in water.

Fourthly, from the last observation we may perceive, that tinctures drawn from the same vegetable or animal substance must differ considerably, according to the state of dryness of these substances, and the dephlegmation of the spirit of wine employed. For a tincture made from moist plants, and with a weak spirit of wine, must contain some gummy and saline principles, which could not be contained in a tincture made with the same plants perfectly dried, and a spirit of wine perfectly rectified.

Fifthly, as many chemical experiments shew that substances naturally unsoluble in any certain menstruum, may be rendered soluble in that menstruum by

by ſome other intermediate ſubſtance; and as, amongſt the vegetable and animal principles, ſome ſuch intermediate ſubſtances may exiſt; we cannot therefore affirm that ſpirituous tinctures contain no other of theſe principles but ſuch as are naturally ſoluble in ſpirit of wine; but we rather think that they probably do contain other principles. This ſubject has not been examined ſufficiently to enable us to ſpeak upon it in a leſs vague and general manner than we now do. *See* ANALYSIS *by* MENSTRUUMS, *and* SPIRIT (ARDENT).

DCXCIX. TIN-GLASS. This name is frequently given to the ſemi-metal biſmuth. *See* BISMUTH.

DCC. TOBACCO. (*b*)

DCCI. TOPAZ. (*i*)

DCCII. TORREFACTION. This name is given to a kind of calcination by which ores are deprived of the volatile mineraliſing ſubſtances, the ſulphur and arſenic which they contain. It is alſo applied to ſignify the roaſting of ſome pharmaceutical preparations. Thus, for inſtance, we ſay *torrefied rhubarb*, &c.

DCCIII. TRAGACANTH (GUM). *See* GUM.

DCCIV. TRIPOLI. (*k*)

DCCV. TRITURATION is an operation which conſiſts in the mechanical diviſion of bodies, and is executed by the ſame methods, and by the ſame inſtruments, that are employed for other diviſions of this kind; that is to ſay, in mortars, upon porphyries, and in mills. *See* DIVISION. This word is generally applied to denote the diviſion that is made of ſeveral bodies together, to unite them with each other; as, for inſtance, the extinction of mercury in the operation of ethiops mineral, and others ſimilar.

DCCVI. TURBITH MINERAL. This name is given to a preparation of mercury made in the following manner.

(*b*) TOBACCO. The leaves of this plant being diſtilled in a retort, without addition, yield an acrid, empyreumatic, poiſonous oil. Tobacco loſes its virulence by long coction in water. From an ounce of American tobacco, water extracted four drams and thirty grains; and from an ounce of the ſame tobacco, ſpirit of wine extracted one dram and thirty grains. The ſpirituous extract was ſtronger than the aqueous. The former had a fine green color; the latter was yellowiſh-brown. The diſtilled water and ſpirit of tobacco have no taſte or ſmell. *Neuman.*

(*i*) TOPAZ is a precious ſtone, of a golden color, the fourth in hardneſs from diamonds. Mr. Pott has made ſome curious experiments on the Saxon topaz. He found that this ſtone could not be fuſed with even eight times its weight of fixed alkali, but that it was vitrifiable by addition of half its weight of borax, or of thrice its weight of chalk. It was alſo fuſed by calxes of lead or of copper, and by fuſible ſpar, but not by nitre.

This ſtone may be imitated by fuſing a mixture of two ounces of powdered rock-cryſtal with ſeven ounces of red-lead.

(*k*) TRIPOLI is an earth conſiſting of very fine particles. It is uſed for poliſhing hard bodies. Tripoli is not fuſible in the fire. Its colors are various; grey, yellow, white. It becomes more hard and compact in the fire, as clay does; and from this property probably it has been conſidered as an argillaceous earth; tho' it does not appear to have been ſufficiently examined. It has been imagined to be a powder formed by the decompoſition or mouldering of jaſper. Neuman ſays, that by diſtilling two ounces of it, he obtained two ſcruples of a weak marine acid, and a ſmall portion of ſal ammoniac; that by diſtilling a mixture of this earth and nitre he obtained an aqua regia; and that of ſixty grains of Tripoli, one grain was ſoluble in concentrated vitriolic acid, two in diluted vitriolic acid, three in ſpirit of ſalt, five in ſpirit of nitre, eleven in aqua regia, and ſeven grains in cauſtic fixed alkali.

Some mercury is put into a glaſs-retort, and upon it is poured an equal weight of concentrated vitriolic acid, or more, according to the degree of concentration of this acid. Theſe matters are to be diſtilled together in a ſand-bath till nothing remains in the retort but a dry ſaline ſubſtance, which is a combination of mercury with vitriolic acid. The union of theſe two matters cannot be directly effected but by this proceſs, becauſe the vitriolic acid cannot attack mercury unleſs it be highly concentrated, and becauſe this concentration cannot be performed ſo well in open as in cloſe veſſels. *See* CONCENTRATION. Beſides, the heat in this operation favors conſiderably the action of the acid upon the mercury. The acid which paſſes into the receiver during the diſtillation, is very ſuffocating and ſulphureous; which qualities it receives from the phlogiſton of the mercury.

The white ſaline maſs left at the bottom of the retort is to be put into a large veſſel, and upon it large quantities of hot-water are to be poured at ſeveral different times. This water weakens the acid, takes it from the mercury, which is then precipitated towards the bottom of the veſſel in form of a very ſhining yellow citron-colored powder. This yellow mercurial powder, having been well waſhed, is called *turbith-mineral*, and is a very powerful emetic.

The water with which it is waſhed contains the acid that was united with the mercury; but it alſo contains a little mercury, that remains in a ſaline ſtate, and is ſoluble in water, by means of the very large quantity of acid.

Moſt chemiſts, eſpecially Mr. Rouelle, have believed that a portion of vitriolic acid remains united with the turbith mineral, but too little to render it ſoluble in water. On the contrary, Mr. Beaumé, having examined this matter, affirms that turbith mineral contains no acid, when it has been ſufficiently waſhed; and that by frequently boiling this preparation in a large quantity of diſtilled water, not a veſtige of acid will adhere to it.

Turbith mineral may alſo be made, by precipitating mercury from its ſolution in nitrous acid by means of vitriolic acid, or of ſome vitriolic ſalt. For this purpoſe the nitrous acid muſt be well ſaturated with mercury: for if it contains any unſaturated acid, no turbith mineral will appear upon adding either vitriolic ſalts or pure vitriolic acid. Hence miſtakes may be committed in making experiments to diſcover the preſence of vitriolic acid by means of a ſolution of mercury, as is frequently done.

We ought alſo to obſerve, that turbith mineral becomes yellow only by being deprived of the adhering vitriolic acid, and that it remains white till it has been waſhed with a large quantity of water; in general, the more perfectly it is deprived of acid, the deeper yellow color it acquires.

Turbith mineral has been formerly celebrated for the cure of the venereal diſeaſe, but it is now little uſed, becauſe preferable mercurial remedies have been diſcovered. *See* ACID (VITRIOLIC), *and* MERCURY.

DCCVII. TURPENTINE. (*l*)

(*l*) TURPENTINE is a reſinous juice extracted from ſeveral trees. Sixteen ounces of Venice turpentine being diſtilled with water, yielded four ounces and three drams of eſſential oil; and the ſame quantity diſtilled without water, yielded with the heat of a water-bath, two ounces only. When turpentine is diſtilled or boiled with water till it becomes ſolid, it appears yellowiſh; when the proceſs is further continued, it acquires a

DCCVIII. TUTENAG. (m)

a reddish brown color. In the first state it is called boiled turpentine, and in the second, colophony or common resin. On distilling sixteen ounces in a retort with an open fire encreased by degrees, we obtain, first, four ounces of a limpid colorless oil; then two ounces and two drams of a thicker yellow oil; and lastly, two ounces and a dram of a dark-brownish red empyreumatic oil, of the consistence of a balsam, and commonly distinguished by that name.

The *essential oil* commonly called *spirit of turpentine* cannot without singular difficulty be dissolved in spirit of wine, though turpentine itself is easily soluble in that spirit. One part of the oil may be dissolved in seven parts of rectified spirit of wine; but on standing a while, the greatest part of the oil separates and falls to the bottom. *Neuman.*

(*m*) TUTENAG. This name is given in India to the semi-metal *zinc*. It is also sometimes applied to denote a white metallic compound brought from China, called also *Chinese copper*, the art of making which is not known in Europe. It is the best imitation of silver which has been made. It is very tough, strong, malleable, may be easily cast, hammered and polished; and the better kinds of it, when well manufactured, are very white, and not more disposed to tarnish than silver is.

V.

DCCIX. VALERIAN. (*n*)

DCCX. VENUS is the name of a planet, which chemiſts have alſo applied to ſignify copper.

DCCXI. VERDIGRISE. Verdigriſe is copper corroded and reduced to a very beautiful green ruſt, by a vinous acid. This matter, which is very uſeful to painters, is conveniently manufactured at Montpellier; the wines of Languedoc, of which that city is the capital, being very proper for this preparation.

The following proceſs for making verdigriſe is deſcribed by Mr. Monet of the Royal Society of Montpellier, and is publiſhed among the Memoirs of the Academy for the years 1750 and 1753.

Vine-ſtalks well dried in the ſun are ſteeped during eight days in ſtrong wine, and afterwards drained. They are then put into earthen pots, and upon them wine is poured. The pots are carefully covered. The wine undergoes the acetous fermentation, which in ſummer is finiſhed in ſeven or eight days, but requires a longer time in winter, although this operation is always performed in cellars. When the fermentation is ſufficiently advanced, which may be known by obſerving the inner ſurface of the lids of the pots, which during the progreſs of the fermentation is continually wetted by the moiſture of the riſing vapors, the ſtalks are then to be taken out of the pots. Theſe ſtalks are by this method impregnated with all the acid of the wine, and the remaining

(*n*) VALERIAN. An ounce of the dry root of valerian yielded with rectified ſpirit of wine three drams and ſix grains of reſinous extract, and the ſame quantity with water yielded four drams and twenty-one grains. The diſtilled ſpirit is ſlightly, and the diſtilled water is ſtrongly impregnated with the ſmell of the valerian, but no ſeparable oil is obtained. The moſt active preparation is the ſpirituous extract, which contains all the uſeful matter of the root. *Neuman*.

liquor

liquor is but a very weak vinegar. The ſtalks are to be drained during ſome time in baſkets, and layers of them are to be put into earthen pots with plates of Swediſh copper, ſo diſpoſed that each plate ſhall reſt upon and be covered with layers of ſtalks. The pots are to be covered with lids, and the copper is thus left expoſed to the action of the vinegar, during three or four days or more, in which time the plates become covered with verdigriſe. The plates are then to be taken out of the pots, and left in the cellar three or four days; at the end of which time they are to be moiſtened with water, or with the weak vinegar above-mentioned, and left to dry. When this moiſtening and drying of the plates has been thrice repeated, the verdigriſe will be found to have conſiderably encreaſed in quantity, and it may then be ſcraped off for ſale.

A ſolution or eroſion of copper, and conſequently a verdigriſe, may be prepared by employing ordinary vinegar, inſtead of wine, as is directed in the above proceſs. But it would not have the unctuoſity of ordinary verdigriſe, which quality is neceſſary in painting. Good verdigriſe muſt be prepared by means of a vinous acid, or ſolvent, half acid, and half ſpirituous. Accordingly, the ſucceſs of the operation depends chiefly on the degree of fermentation to which the wine employed has been carried: for this fermentation muſt not have been ſo far advanced that no ſenſibly vinous or ſpirituous part remained in the liquor.

Verdigriſe is uſed for painting, as it furniſhes a fine green color, when mixed with oil. It enters alſo as an ingredient into ſeveral plaiſters and ointments. In Chemiſtry, verdgriſe is uſed for the extraction of radical vinegar, and for the preparation of *cryſtals of verdigriſe*, or *of Venus*. *See* CRYSTALS *of* VENUS, COPPER, *and* VINEGAR.

DCCXII. VERDITER (o).

DCCXIII. VESSELS (CHEMICAL) *and* UTENSILS.

We have ſhewn at the article LABORATORY, how a chemical laboratory ought to be diſpoſed, and the principal utenſils with which it ought to be furniſhed. At the article FURNACES, we have mentioned whatever is eſſential to be known concerning thoſe inſtruments. Laſtly, we have deſcribed under each particular name, the principal veſſels employed in chemical operations. Nothing therefore remains but to make here a kind of enumeration, uſeful to thoſe who would furniſh a laboratory; which enumeration may be conſidered as a compleat ſupplement to that which is given at the article LABORATORY.

(o) VERDITER is a blue pigment obtained by adding chalk or whiting to the ſolution of copper in aqua fortis. It is prepared by refiners of ſilver, who employ for this purpoſe the ſolution of copper, which they obtain, in the proceſs of parting, by precipitating ſilver from aqua fortis with plates of copper. *See* PARTING. It is ſaid that a fine coloured verditer cannot be obtained from a ſolution of copper prepared by diſſolving directly that metal in aqua fortis; and that the ſilver is neceſſary. We know that it is actually made by the refiners only. Dr. Merret ſays that it is prepared in the following manner: a quantity of whiting is put into a tub, and upon this the ſolution of copper is poured. This mixture is to be ſtirred every day for ſome hours together till the liquor loſes its color. The liquor is then to be poured off, and more ſolution of copper is to be added. This is to be repeated till the whiting has acquired the proper color. Then it is to be ſpread on large pieces of chalk, and dried in the ſun.

The

The ancient chemists, and especially the alchemists, have invented vessels of many various kinds and whimsical shapes, suited to their several operations. But now the number and variety of those vessels are much diminished, either because modern chemists have not so much patience for such tedious and perplexed operations as the alchemists had, or because they have found that their operations can be performed with vessels of a simpler form, and less various. Accordingly the vessels required in a laboratory are few and simple, which is certainly an advantage. The chief of these vessels are,

Copper Alembics, with their *refr igeraries*, *worms*, and *receivers*. *See all these words*, and PLATE I.

Alembics of Glass, of *Stone*, and *Earthen-Ware*, of different sizes, with their *receivers*, which are matrasses with longer or shorter necks. *See* PLATE I.

Adopters, which are small receivers with two necks, the use of which to encrease the distance of the receiver from the distilling vessel and the furnace.

Aludels of Earthen Ware. *See* PLATE I.

A Balance. *See this word*.

Balloons, which are matrasses with large bellies and short necks. They are used as receivers. *See* BALLOONS.

Bottles of all kinds and sizes. A great number of these is required in laboratories, to contain the different liquors, and substances that are volatile, deliquescent, or corrosive. The most necessary of these are large glass bottles containing three, four, six pints, or more, of any form, for containing those matters that are used in large quantities. *Crystal-glass Bottles* with glass stopples, to contain all volatile or corrosive liquors. The small bottles or *Phials* are very convenient, and may be used as matrasses in many small operations. *See* MATRASS.

Glass Jars are cylindrical vessels useful for containing many dry and not volatile substances. Their mouths are generally closed with cork or with paper. Large jars are convenient for the mixing of liquors, for precipitations, &c. A great number of these is required of different sizes.

Basons of metal. These are useful for evaporations. They are generally of copper; but as this metal is very liable to be corroded by saline matters, a silver bason is very convenient.

Capsules, or *Dishes* of glass, of stone-ware, and of crystal-glass, which are the best of any. These are used in the evaporations of corrosive matter capable of acting upon metals. Some also are made of crucible-earth, and of plate iron, which are employed for containing the sand of sand-baths.

The *Cone*. This is a cast-iron vessel of the form of a hollow cone, to the point of which is fixed a pedestal, that it may stand firmly, with its point turned downwards. The use of this cone is to receive metallic matters melted with other substances, all which being poured into it, the metallic parts of the mixture sink by their weight to the point of the inverted cone, and are there collected in form of a regulus. The cone ought to be heated, and greased with tallow, before the melted matters are poured into it.

Retorts. *See that word*.

Crucibles are kinds of earthen pots of a cylindrical, conical, or triangular figure, used for fusions of all kinds. They ought to be covered with lids. *See* POTTERY.

Glass

Glaſs Funnels. Theſe ought to be of various ſizes; and are neceſſary for ſmall filtrations, and for the pouring of liquors into bottles.

Ingot-moulds are iron veſſels of a certain thickneſs, of the form of hollow ſemi-cylinders, to which a handle is annexed. The ſurface of their ſemi-cylindrical cavities ought to be very ſmooth. They are of various ſizes. The uſe of theſe veſſels is to receive melted metals into their cavities, the form of which is given to the metals, which are then called *ingots.* We ought always to heat and to greaſe theſe moulds before the melted metal is poured into them. *See* PLATE I. *Fig.* 11.

Mortars. See that word.

Matraſſes are long-necked bottles. Some of theſe have round, and ſome flat bottoms. Some are ſhaped like an egg, and thence are called *philoſophic eggs.* Matraſſes are uſed for *ſolutions and digeſtions.*

Muffles. Theſe veſſels, which ought to be made of crucible earth, have the form of a hollow cylinder divided in the direction of its axis, and cloſed on all ſides, excepting its front. This veſſel repreſents an oblong arch or vault, the hinder part of which is cloſed by a ſemicircular plane, and the lower part or floor of which is a rectangular plane. It is a little oven that is placed horizontally in eſſay and enamelling furnaces, ſo that its open ſide correſponds with the door of the fire-place of the furnace. Under this arched oven ſmall cupels or crucibles are placed; and the ſubſtances contained are thus expoſed to heat without contact of fuel, ſmoke, or aſhes. *See* FURNACE (ESSAY); PLATE I. *Fig.* 9, and PLATE II. *Fig.* 1.

Pelicans. See that word, and PLATE I. *Fig.* 6.

Receivers. See that word, and PLATES I. *and* II.

Circulatory Veſſels. Two matraſſes are ſo called, into the largeſt of which the matter to be operated upon is to be introduced, and the neck of the ſmaller matraſs is to be fitted into the neck of the former, ſo as to be a kind of ſtopple to it. The joining is to be cloſed with a lute ſuitable to the vapors intended to circulate. By means of this apparatus, one or more ſubſtances may be digeſted during a long time without any evaporation, becauſe the vapors which riſe are condenſed in the ſmall matraſs that ſerves as a ſtopple, and continually fall back upon the matter in the great matraſs. It is, as we ſee, a very ſimple apparatus, which produces the ſame effect as the pelican.

Subliming Veſſels. This name was formerly given to a long-necked matraſs, which being covered with a capital, formed a kind of alembic. It was employed in the diſtillation and rectification of very volatile ſubſtances; but ſince we have found that the length of the neck of an alembic is quite uſeleſs, theſe have been quite abandoned. Accordingly, the true ſubliming veſſels are thoſe that are actually employed in ſublimations. *See* ALEMBICS, ALUDELS, MATRASS, *and* SUBLIMATION.

DCCXIV. VINEGAR. Vinegar is a vegetable ſpirituous acid, produced by the ſecond degree of fermentation, or by that fermentation which ſucceeds the ſpirituous, and is called the *acid* or *acetous fermentation.*

From this definition it appears, that wine only or vinous liquors can be changed into true vinegar. Every liquor which has completely undergone the ſpirituous fermentation, is ſpontaneouſly and neceſſarily diſpoſed to the acid fermentation. Accordingly every wine does continually tend to become vinegar, and

and actually is changed into vinegar, sooner or later, according to circumstances; unless this change be prevented by some obstacle to fermentation in general. Vinegar may therefore be made not only from wine of grapes, but also from cyder, beer, and, in a word, from all other wines. But as the wine of grapes is preferable for this purpose, we shall describe the method of converting it into vinegar.

As vinegar is produced by a fermentation, its qualities depend much on the method of exciting and of conducting that fermentation. The wine which is generally converted into vinegar, and which for its cheapness is generally employed for this purpose, is such as has already become sour; although the better and the more spirituous the wine is, and also the more of the vinous spirit that can be retained in the vinegar, the better and stronger this will be. Beccher says, in his *Physica Subterranea*, that having digested wine in order to convert it into vinegar in a bottle hermetically sealed, he found, that although a longer than the ordinary time was required, the vinegar produced was much stronger then when free air is admitted. Mr. Cartheuser also affirms, that the strength of vinegar may be much encreased by adding some aqua vitæ to the wine before it is exposed to the acetous fermentation.

Different methods are practised by manufacturers for making vinegar, who are generally believed to be possessed of some secret for that purpose. Nevertheless no more seems requisite in the preparation of good vinegar, than to employ good wine, and to conduct the fermentation in the most advantageous method; in the same manner as good wine can only be made from good must, and by a well conducted fermentation. The principal part of these operations is performed by nature.

The method of making vinegar consists in mixing the wine to be fermented with its dregs, and its tartar, and in exposing this liquor to a heat of about eighteen or twenty degrees. This fermentation seems to require more heat than the spirituous. It also excites more heat and tumult; and although it ought to be allowed to proceed briskly, yet it is necessary from time to time to check it.

Boerhaave describes, in his Elements of Chemistry, the following process, which seems to be well contrived, for the making of vinegar.

Take two large oaken vats or hogsheads, and in each of these place a wooden grate or hurdle, at the distance of a foot from the bottom. Set the vessel upright, and on the grate place a moderately close layer of green twigs, or fresh cuttings of the vine. Then fill up the vessel with the footstalks of grapes, commonly called the *rape*, to within a foot of the top of the vessel, which must be left quite open.

Having thus prepared the two vessels, pour into them the wine to be converted into vinegar, so as to fill one of them quite up, and the other but half full. Leave them thus for twenty-four hours, and then fill up the half-filled vessel with liquor from that which is quite full, and which will now in its turn be left only half-full. Four-and-twenty hours afterwards repeat the same operation, and thus go on, keeping the vessels alternately full and half-full during every twenty-four hours, till the vinegar be made. On the second or third day there will arise, in the half-filled vessel, a fermentative motion, accompanied with a sensible heat, which will gradually increase from day to day. On the

the contrary, the fermenting motion is almoſt imperceptible in the full veſſel; and as the two veſſels are alternately full and half-full, the fermentation is by that means, in ſome meaſure, interrupted, and is only renewed every other day in each veſſel.

When this motion appears to have entirely ceaſed, even in the half-filled veſſel, it is a ſign that the fermentation is finiſhed; and therefore the vinegar is then to be put into caſks cloſe ſtopped, and kept in a cool place.

A greater or leſs degree of warmth accelerates or checks this, as well as the ſpirituous fermentation. In France it is finiſhed in about fifteen days, during the ſummer; but if the heat of the air be very great, and exceed the twenty-fifth degree of Mr. Reaumur's Thermometer, the half-filled veſſel muſt be filled up every twelve hours; becauſe if the fermentation be not ſo checked in that time, it will become violent, and the liquor will be ſo heated, that many of the ſpirituous parts, on which the ſtrength of the vinegar depends, will be diſſipated; ſo that nothing will remain, after the fermentation, but a vapid liquor, ſour indeed, but effete. The better to prevent the diſſipation of the ſpirituous parts, it is a proper and uſual precaution to cloſe the mouth of the half-filled veſſel, in which the liquor ferments, with a cover made alſo of oak-wood. As to the full veſſel, it is always left open, that the air may act freely on the liquor it contains: for it is not liable to the ſame inconveniencies, becauſe it ferments but very ſlowly.

In the *Dictionnaire Portatif des Arts et Metiers*, another method is deſcribed, by which a very good vinegar is commonly made at Paris from the lees of wine. For this purpoſe all the wine contained in the lees is preſſed out, and put into large caſks, the bung-holes of which are left open. Theſe caſks are put into a hot place; and if the fermentation proceeds too faſt, it muſt be checked by adding more freſh wine. This proceſs is very ſimilar to the foregoing.

The appearances which accompany the acetous fermentation reſemble much thoſe that occur in the ſpirituous fermentation. In both fermentations, an inteſtine motion, a ſwelling, a hiſſing noiſe, and an ebullition, may be perceived. There are nevertheleſs eſſential differences between them. Beſides that the products of the vinous and acetous fermentations differ exceedingly, the heat produced by the former is ſcarcely ſenſible, while that produced by the latter is conſiderable. Secondly, we have reaſon to believe, that the vapour which exhales from vinegar during fermentation is not noxious, as the vapor of fermenting wine is; at leaſt, it has not been obſerved to produce ſuch bad effects. On the contrary, as the acid of vinegar more and more diſengages or unfolds itſelf, it ſeems to acquire more power to bind and retain the inflammable principle, which is the truly dangerous part of theſe vapors. Laſtly, vinegar does not depoſit tartar as wine does, even although it has been made with wine that had not depoſited its tartar. But the ſediment of vinegar is a viſcid, oily, and very putreſcent matter. The grape-ſtalks uſed in the making of vinegar, to promote and encreaſe the fermentation, are covered over with this matter during the operation. They are generally waſhed clean, and carefully preſerved, to promote the fermentation of more vinegar; becauſe the acid with which they are ſoaked acts powerfully as a leaven or ferment. The caſks alſo which have been uſed for the preparation of vinegar are to be cleanſed

from the above-mentioned viscid matter, and kept for the same use, as they are rendered fitter than new casks for the preparation of vinegar.

When the acetous fermentation is finished, the nature and the character of the liquor that has undergone it are totally changed. Wine has a taste and smell, partly spirituous, somewhat acid; but in good wine the spirit so much prevails over the acid, that the latter is scarcely perceptible. The taste and smell of vinegar also is partly acid and partly spirituous; but the former quality so entirely prevails, that the latter is almost totally concealed.

We cannot form any very clear and distinct knowledge of the manner in which Nature performs these changes in fermenting liquors. The properties of wine and vinegar prove, that the acetous fermentation unfolds in a very singular manner the acid parts of wine, and intimately combines them with the inflammable spirit. Hence, by changing wine into vinegar, its ardent spirit is so covered by the large quantity of acid, that it is no longer perceptible; that it now cannot affect the head and intoxicate; and that if it be distilled, the first liquor that rises with a heat less than that of boiling water is not an ardent spirit, as when wine is distilled, unless the vinegar be too new, and the acetous fermentation has not been completely finished; in which case the vinegar yields a little ardent spirit: but when old vinegar is distilled, the liquor that rises first is a slightly acid phlegm, which contains the most volatile, the most odoriferous, and the most spirituous part of the vinegar.

The acid of vinegar is employed in many chemical and pharmaceutical preparations, for which not common vinegar, but the acid spirituous part of vinegar that is obtained by distillation, called *distilled vinegar*, is chiefly employed.

The process of distilling vinegar is very simple. A quantity of good ordinary vinegar is put into a large cucurbit or still, which ought to be made of stone-ware, and not of metal, as the acid of vinegar is capable of acting upon most metals. This cucurbit is sunk in a deep furnace, so that five or six fingers breadth only near its neck appears. The neck is to be carefully luted with clay all round the furnace, that the capital may not be heated too much. A capital and a glass receiver are then to be fitted, and the distillation is to be begun, with a very gentle heat. The acid spirituous liquor passes by drops into the receiver. This liquor is white, transparent, penetrating, somewhat empyreumatic, and disengaged from an acid, but not spirituous substance, and also from an extractive saponaceous matter, both which are contained in ordinary vinegar. These latter substances remain in the still with the coloring matter, and form together an extremely acid extract of vinegar. This residuum contains also some tartar, and by incineration yields much fixed alkali, as all matters belonging to vines, grapes, or wine, do.

We should be much mistaken if we believed that the acid spirituous portion of the vinegar that rises in this distillation, is a stronger acid than the vinegar itself. Vinegar is not distilled with an intention to concentrate it, but only to disengage it, as we have said, from its extractive part. The acid which this part contains is not, properly speaking, vinegar, but is oily, not spirituous, less volatile than the former, or even than water. Accordingly, the acid obtained in this distillation, when well conducted, is more spirituous and also more watery than the acid of the residuum.

Chemists have attempted different methods of concentrating distilled vinegar. Stahl has taught us the best method for depriving it of its water without any alteration. This method consists in exposing it to a cold sufficiently intense to freeze its watery part, which is afterwards separated in lumps of ice from the more acid part. Thus the acid of vinegar may be considerably concentrated. *See the* CONCENTRATION *of* VINEGAR *by* FROST.

The acid of vinegar may be more effectually concentrated by combining it with alkalis, earths, and metals, as any other acid may. Thus by drying perfectly neutral acetous salts with fixed bases, and afterwards by decomposing them, either by the mere action of the fire, or by means of concentrated vitriolic acid, we obtain the stongest acetous acid that can be produced. This acid is called *radical vinegar*. *See* SPIRIT *of* VENUS.

The acid of vinegar dissolves all substances upon which other acids can act, and forms with them neutral salts, some of which have particular names, but which all might be called *acetous salts*.

With calcareous earth this acid forms salts that in crystallizing shoot into silky ramifications and vegetations. These salts are named from their earthy bases, *salt of chalk*, *salt of crabs-eyes*, &c.

With fixed vegetable alkali it forms a very pungent and very deliquescent salt, called *regenerated tartar*, or *terra foliata tartari*. *See* TERRA FOLIATA.

With fixed mineral alkali it forms a neutral crystallizable salt.

With volatile alkali it forms *an acetous ammoniacal salt*, called *spirit of Mindererus*.

All the combinations of the acetous acid with metallic substances have not been yet examined. The combinations of this acid with lead and with copper are best known, because they furnish several preparations used in painting, and some other arts. This acid united with copper forms *verdigrise* and *crystals of Venus*; and with lead forms *cerufs*, and *salt or sugar of lead*. *See these several articles*. The vinegar in which lead is dissolved is called *vinegar of lead*, and is sometimes used as a cosmetic, for repelling cutaneous eruptions. But this cosmetic ought not to be employed but under the direction of a prudent physician, as it may occasion a dangerous translation of the morbid humour to other parts.

Mercury dissolved first by nitrous acid, and afterwards precipitated by fixed alkali, is quickly soluble in vinegar, with which it forms a mercurial acetous salt. The crystals of this salt are shining silver-like plates, not very soluble in water. *See* MERCURY.

Vinegar very much concentrated, as the rectified spirit of Venus, or radical vinegar, being distilled with equal parts of highly rectified spirit of wine, furnishes a liquor which has all the essential characters of ether, or rather is a true ether, called *acetous ether*. The discovery of this ether was lately made by the Count de Lauraguais. *See* ETHER (ACETOUS).

Vinegar being an oily, spirituous, vegetable acid is much weaker than mineral acids, which are less compounded. Accordingly all acetous neutral salts may be decomposed by any mineral acids, excepting the vitriolic acid when very much sulphurated, which cannot be considered as a pure acid.

According to Mr. Gellert's table, the affinities of the acetous acid are in the following order: Inflammable principle, zinc, iron, copper, lead, and bismuth.

Gold, silver, tin, and mercury, are marked in this table as incapable of uniting with this acid.

Vinegar is very useful, not only in ordinary life as an agreeable seasoning for many kinds of food, but also in medicine, in chemistry, and in several arts.

This acid is in general antiseptic, and is considered as incisive and aperitive. It is used as a vehicle in many preparations which possess these qualities. Thus *simple oxymel* is a syrup made of honey and vinegar. Such also are *oxymel of squills*, and several other compound vinegars for the use not only of medicine, but also of the toilette; receipts for all which are found in dispensatories. A very important medicinal virtue has been attributed to vinegar, namely, that of curing the canine madness. Mr. Buchoz, in a work entitled, *An Historical Treatise of Plants growing in Lorraine and the Three Bishopricks*, affirms, that several successful trials have ascertained the efficacy of vinegar against the ill effects arising from the bite of mad dogs, when it is given in the quantity of a pound each day, divided into three doses; one to be taken in the morning, another at noon, and the third in the evening. The discovery of this quality of vinegar was made accidentally at Udina, in Trioul, a province belonging to Venice, by an inhabitant of that town, who having been seized with canine madness, was cured by drinking a glass of vinegar by mistake, instead of some medicine that had been prepared for him.

We have already mentioned the use of vinegar in several chemical preparations, particularly of ceruss and of verdigrise.

DCCXV. VINEGAR (DISTILLED). This is the spirituous acid of vinegar obtained by distillation. *See the preceding article.*

DCCXVI. VINEGAR (RADICAL). *See* SPIRIT *of* VENUS.

DCCXVII. VINEGAR *of* LEAD. Is a solution of lead or of ceruss in distilled vinegar. *See the articles* LEAD *and* VINEGAR.

DCCXVIII. VITRIFICATION. Vitrification is one of the most curious and most important operations in chemistry. The product of this operation is Glass; a matter which, when well made, is valuable for its great hardness, beauty, and perfect transparency. These principal and essential qualities of glass render it very extensively useful in ordinary life, in natural philosophy, in chemistry, and in many arts. Almost any form may be given to glass, and all kinds of vessels and utensils may be formed of it, which are capable of resisting the most powerful corrosives and solvents. Glass is capable of receiving and preserving the finest polish. Its properties of transmitting and refracting the rays of light, and of reflecting these rays when one of its surfaces is covered with a metallic coat, render it very useful for constructing mirrors, telescopes, microscopes, and all kinds of optical glasses; for collecting, separating, and decomposing the rays of light; and for exhibiting many wonderful catoptrical and dioptrical appearances and experiments. If to these admirable properties we add that of imitating the many brilliant precious stones, opake or transparent, we shall easily be convinced that perfect glass is one of the most beautiful and excellent productions of human industry.

The art of making glass is dependant on chemistry in all its parts. In its principles it is simple, but extensive in its detail, and difficult in its practice. The extent of this art does not permit us to enter into the particulars, or into its

its ſeveral branches. In this article we ſhall only endeavor to explain the chemical principles upon which the art depends, and which may direct experimental philoſophers as well as intelligent artiſts in their reſearches to improve it.

Perfect glaſs, or the moſt beautiful factitious cryſtal, is perfectly ſimilar in appearance to the whiteſt and moſt tranſparent natural vitrifiable ſtones. The only ſenſible difference between theſe natural and artificial productions is, that the latter are much leſs hard and more fuſible than natural cryſtal, or any other vitrifiable ſtone. In fact, pure glaſs or artificial cryſtal is eſſentially of the ſame nature as vitrifiable ſtones; or we may rather ſay, that it is vitrifiable earth itſelf rendered more fuſible only by certain additions, as we ſhall ſoon ſhew.

The moſt ſimple and elementary of all earths, called by chemiſts *vitrifiable earth*, forms the hardeſt and moſt tranſparent of all natural bodies, when its integrant parts are united together in a due ſtate of aggregation: but the parts of vitrifiable earth cannot form this aggregation, unleſs they have been previouſly ſo much ſeparated from each other, that they poſſeſs a mobility which enables them to unite together according to their natural tendency: the integrant parts of elementary earth may acquire this mobility by two methods; namely, by the interpoſition of the parts of water, or of thoſe of fire.

Almoſt all the vitrifiable ſtones that we know, as diamonds, rock-cryſtal, and other hard tranſparent ſtones, appear to have been once diſperſed in infinitely ſmall molecules through much water, from which they have afterwards been depoſited, and then have united together and formed the very hard tranſparent maſſes which we now ſee. The regular and uniform cryſtallization of theſe precious ſtones is an evident proof of this truth.

Poſſibly ſome of theſe ſtones may have been formed by fire, and by a true fuſion. Perhaps even this terreſtrial globe has been once, as Mr. de Buffon thinks, one ſphere of melted glaſs, or one immenſe diamond, the outer cruſt of which only has been changed by the elements, while the interior parts ſtill remain in their vitrified ſtate *(p)*: but we certainly know, that of the two abovementioned methods by which pure ſolid maſſes of vitrifiable earth may be formed, that of the diviſion and elaboration by water cannot be practiſed by human art, on account of the many ages required for the operation.

By the ſecond method, namely, *fuſion*, the time required for which is better adapted to the ſhortneſs of our lives, we certainly might, with a ſufficient degree of heat, melt vitrifiable earth, and all other kinds of earths; ſince theſe, when ſufficiently purified, are reduced to the nature of vitrifiable earth; and we might convert theſe earths into maſſes of cryſtal, or of hard tranſparent ſtones,

(p) Mr. Buffon conjectures, that the earth, as alſo the other planets, might have been parts knocked off from the ſun by a comet falling upon its ſurface; that they received from the impulſe of the comet their progreſſive motion; and alſo, by the obliquity of the ſtroke, their motion round their own axes; that the earth was then in a vitrified and fluid ſtate; and that a vapor exhaled from its ſurface by the violent heat, the groſſer parts of which, being afterwards condenſed, formed water, and the leſs denſe remaining ſuſpended formed air. We have not heard that many philoſophers have adopted this theory of the formation of the planets.

as perfect as the natural precious stones. In a word, nothing but a heat sufficiently intense is required to melt any earthy matter, and to convert it into a diamond, as brilliant and as hard as the most perfect natural diamonds: but here a great, and hitherto unsurmountable difficulty occurs, namely, to produce a heat sufficiently intense to melt the most pure and simple vitrifiable earth; for the most violent heat that art has ever produced is insufficient to melt even many of the common impure earths and stones, and is therefore much less capable of melting that earth, which, because it is the simplest and purest, is also the most unfusible of all natural bodies. *See* EARTH.

Hence we conclude, that although we know by what means the parts of the purest earthy principle may be so united as to form bodies similar to the natural precious stones, yet we cannot possibly put these means in execution: but if we cannot artificially produce solid masses of pure earth exactly similar in all their properties to the natural precious stones, we can however very well imitate these beautiful natural productions, not in their hardness and unfusibility, but in their transparency and lustre; that is, in their most obvious and striking qualities, by means of compositions of glass or factitious crystal. The solution of this problem is founded on the following principles.

First, pure and elementary earth, which makes the principal basis of all vitrifications, and therefore called vitrifiable earth, is indeed unfusible with regard to us: but we know, that certain very fusible substances are capable of uniting intimately with this earth, and of communicating to it some of their fusibility; so that by their means we may reduce it to a perfect fusion.

Secondly, the substances capable of acting upon the earthy principle are the inflammable principle or phlogiston, and several saline matters: but we may remark, that as these substances do only act as fluxes by uniting intimately with the vitrifiable earth, and while they themselves make part of the glass; and also, as the integrant parts of these fluxes are not capable of forming either with each other, or with the parts of vitrifiable earth, so strong an adhesion as that which can be formed between the parts of the pure vitrifiable earth; it follows, that all factitious crystal must be much less hard than natural crystals, or other hard stones; since these contain only pure vitrifiable earth.

Thirdly, in consequence of the principle, that all compound bodies partake of the properties of their component parts, factitious crystals ought to partake so much more of the properties of inflammable and saline matters, and ought to be removed so much more from those of pure vitrifiable stones, as they contain a larger quantity of those matters. Accordingly we find, that the smaller quantity of flux that is contained in glass, the greater hardness, lustre, and resemblance to natural stones it has, provided the fusion has been compleat. Thus glass is so much more perfect, as it possesses more of the properties of vitrifiable earth.

These principles, which are incontestable, being once understood, are easily applicable to the art of making glass, as we shall shew: since, if we could produce a fire sufficiently intense, and had furnaces and vessels capable of sustaining it, we should make glass equal to the precious stones; it is therefore evident, that the most important object in vitrification is to have furnaces capable of producing the greatest heat, and pots or crucibles capable of resisting,

ing, during a long time, this heat, and alſo the action of the vitreſcent matter that they contain. At the articles of this Dictionary, CLAY and POTTERY, may be ſeen what are the beſt earths, or mixtures of earths, for the conſtruction of furnaces, and of pots or crucibles. We ſhall here only repeat, that theſe pots ought to be made entirely of the moſt refractory and pureſt clay, well waſhed and cleanſed from all ſandy, ferruginous, and pyritous matters, and mixed with a certain proportion of the ſame clay baked, and pounded not very finely. The quantity of baked clay that ought to be mixed with the crude clay, to prevent the pots from cracking when dried, or when expoſed to violent heat, is not abſolutely determined, but varies in different glaſs-houſes, according as the crude clay employed be more or leſs fat, as it is called: but Mr. D'Antic, Doctor of Phyſic, a very able chemiſt, and particularly converſant about every thing relating to the theory and practice of glaſs-making, in an excellent Memoir upon this ſubject, propoſes a very good method of aſcertaining the quantity of burnt clay that ought to be mixed with crude clay in the compoſition for pots and furnaces. This method conſiſts in mixing the burnt and crude clay in different proportions, and in forming cakes of theſe ſeveral mixtures, each of which is one inch in thickneſs, and four inches in each of the other two dimenſions. When theſe cakes have been ſufficiently and very ſlowly dried, and are expoſed to a violent heat, till they become as hard, and contract as much in their dimenſions as they can, they are to be then examined; and the cake which has ſuffered a diminution of its bulk equal only to an eighteenth part is made of the beſt proportions. According to the ſame author, moſt clays require that the proportion of the burnt ſhould be to the freſh as four to five.

The ovens and furnaces are different according to the quantity of materials to be vitrified. For experiments and eſſays, we know none better than the melting furnace deſcribed at the article FURNACE, and which muſt be heated with charcoal. In large works wood or foſſil coal are uſed, and the furnaces are ſo conſtructed that the flame of the fuel circulates and burns within very intenſely. As theſe furnaces vary much in different countries and glaſs-houſes, and as a deſcription would not be very intelligible without figures, we ſhall refer the reader to other works in which theſe ſeveral furnaces are deſcribed and repreſented, particularly to the French edition of Neri's Art of Making Glaſs, with Notes by Merret and by Kunckel, and to the above quoted Memoir of Mr. D'Antic. We ſhall here ſay only in general, that theſe furnaces are placed under large and lofty buildings called *halls*; that they are covered with a vaulted roof; and that they have no chimney, but only lateral openings through which the melted glaſs is drawn from the pots. Under theſe openings is built a kind of platform or banquette, on which the pots containing the glaſs ſtand, one of which is oppoſite to each opening. In the middle of the furnace, below the banquette, is a ſpace, a-croſs which iron bars are laid. In this ſpace, which communicates with a large cavity below, called the aſh-hole, the fuel is placed. In theſe furnaces, which have not any chimney, as we have ſaid, the fire is nevertheleſs very intenſe. This intenſe heat is occaſioned by the great capacity of the furnace, by means of which a ſtrong draught of air paſſes continually from the aſh-hole. Beſides, the flame, being vividly agitated by air, and not being drawn out of the furnace by any chimney, circulates in every

every direction within the furnace, and produces a very violent heat. Most glass-house furnaces have also hollow towers that communicate with the cavity of the furnace, and which therefore encrease the capacity of the whole. In these the heat is not nearly so intense as in the furnace. They are employed to contain the *fritt*, or the pieces of manufactured glass that are to be annealed. Such is the general disposition of the furnaces of glass-houses.

The good condition of the pots and furnaces is, as we have observed, the most important and essential matter to be considered in the operations of making glass. Next to that, is the consideration of the kinds and proportion of the fluxes. Of these we may observe two kinds, namely, the inflammable and the saline. As we cannot obtain the pure inflammable principle, we must, when we intend that it should enter into the composition of glass, chuse for this purpose some of the earthy substances with which it is found naturally combined; and these are particularly metallic earths, which are best adapted for conveying phlogiston into vitreous compositions: but all these earths are not equally fit for this purpose. All metals are composed of an earthy matter intimately combined with a sufficient quantity of the inflammable principle to be very fusible, and, at the same time, very opake. Some of these metals, namely, those called *perfect*, are unalterable by fire, and cannot be entirely, or even partly, deprived of phlogiston: but as every metallic substance is incapable of uniting with earthy matters, while it retains its metallic state, therefore no perfect metal can be vitrified. The case is different with those metallic substances, the phlogiston of which may be burnt, or otherwise destroyed. The earths or calxes of most, perhaps of all combustible metals, when not perfectly deprived of all their phlogiston, are capable of being reduced to a vitreous state, by means of their remaining inflammable principle. As they are not then in a metallic state, they can facilitate the fusion of vitrifiable earths, may contract with these an intimate union, and reduce them to a state of perfect vitrification: but these phlogisticated calxes of imperfect metals promote vitrification more or less, according to their particular natures. Some of these, as, for instance, tin, cannot be without great difficulty brought to that precise degree of calcination that is necessary to vitrification; because the heat required for this purpose deprives them of all their phlogiston, and renders them in a high degree refractory. Others, in whatever manner they be calcined, either retain too little phlogiston to be sufficiently fusible, although they still retain enough to give them color; or, if they be not calcined so much as to lose their fusibility, they cannot be melted but into opake masses, so nearly in a metallic state that they cannot be united intimately with vitrifiable earths. Such, especially, are the earths of iron and of copper.

Of all metallic earths, that of lead is fittest for vitrification. This metal, which contains a large portion of phlogiston, is quickly deprived of so much of it, that it loses its metallic state, and is easily melted into a transparent vitreous mass; but it has, at the same time, this remarkable property, that when once it has lost as much phlogiston as is necessary to dispose it to vitrification, its calx strongly retains as much of it as is necessary to give to it its greatest degree of vitrescibility; and that it may be sooner dissipated into vapors by the continued action of a very intense fire, than it can be changed into an earth

totally

totally dephlogisticated, and consequently refractory, like the calxes of tin and of regulus of antimony. Besides, the fusible earth of lead is one of these that retain the least color. All these qualities render it preferable to any other metallic earth for the purposes of vitrification. The earth of bismuth, which in the above-mentioned properties resembles the earth of lead, may probably be employed with equal success: but as the calxes of lead are much more common than those of bismuth, the use of this semi-metal is not known to manufacturers of glass.

In whatever manner the calx of lead has been prepared, provided it be really in a calcined and not in a metallic state, it may be used in vitrification. Accordingly, the grey calx, or ashes of lead, massicot, red-lead, litharge, ceruss, and all the precipitates of lead, separated from acids by unmetallic intermediate substances, being mixed with sand or any other vitrifiable stone, and exposed to a sufficient degree of fire, do always promote the fusion of these matters, and form with them glasses more or less hard and transparent, according to the strength of the fire and the proportion of the ingredients.

The earth of lead constantly retains, as we have said, enough of the inflammable principle to preserve its fusibility. When it is exposed singly to the fire, it vitrifies with a very moderate heat. It has more phlogiston than is requisite for its vitrification. The fusibility, fluidity, and activity of this glass of lead, when pure, are so great, that it cannot be contained in any crucible, all which it easily pervades: therefore pure glass of lead is never made. But as the calx of lead has more phlogiston than is required for its own vitrification, it may divide this excess of inflammable principle with any unmetallic earths with which it is mixed, and thus may produce their fusion and perfect vitrification. The glasses formed by a mixture of calx of lead with unmetallic earths have more consistence, hardness, and less fusibility, than pure glass of lead. The proportions of calx of lead and of sand employed in these kinds of glass are from one part to two of calx of lead, to one of sand, or of ground flints.

We may observe upon the subject of glasses that contain no other flux than phlogiston or metallic earths, of lead, or of any other metal, that none of them are perfectly white, but are all more or less colored; because phlogiston is, as chemists know, the principle of colors. Secondly, these glasses have a greater density or specific gravity than any natural crystalline stone, all metallic earths being heavier than any that are not metallic.

Thirdly, metallic glasses are generally somewhat less brittle, are less liable to be broken by the alterations of heat and cold, and have more of a certain smoothness, or, as it were, unctuosity, not easily to be described, than glasses made altogether of unmetallic earths. These properties can only be attributed to the inflammable principle, a pretty considerable quantity of which is united with them. As these latter qualities of glass are valuable, a certain quantity of calx of lead generally enters into the composition of most fine glasses, which are distinguished from ordinary glass by the name *crystal-glass*.

From what we have said concerning the properties of metallic earths in vitrification we may perceive, that the more calx of lead, or other metallic earth, enters into the composition of any glass, the more fusible, soft, colored, and

denſe this glaſs is; and reciprocally. The colors given to glaſs by calxes of lead are ſhades of yellow.

Saline ſubſtances are the ſecond kind of fluxes uſed in vitrification: but all theſe ſubſtances are not equally fit for this purpoſe; not that they are not all very fuſible, but for ſeveral reaſons hereafter to be mentioned.

Firſt, neither the pure and diſengaged acids, nor volatile alkalis, nor ammoniacal ſalts can be employed as fluxes in vitrification, becauſe none of theſe ſaline matters is ſufficiently fixed. Their volatility is ſo great, that they may be totally diſſipated by fire before they could act in any degree upon vitrifiable earth.

Secondly, none of the neutral ſalts with baſis of fixed alkali, containing either vitriolic acid or marine acid, can be employed as fluxes in vitrification. This proceeds, not from their want of fuſibility, or of the neceſſary degree of fixity, but from the union of the acid and the alkali; which is ſo ſtrong, that they cannot act with ſufficient force upon other ſubſtances, and particularly upon vitrifiable earth. The ſaline matters fit for vitrification are, *fixed alkalis*, vegetable and mineral; *nitres* with baſis of fixed alkali; *ſedative ſalt*, and *borax*; *fuſible ſalt of urine*, or rather *phoſphoric acid*.

Of all ſaline matters, fixed alkalis, vegetable and mineral, are moſt frequently uſed in vitrification. Theſe alkalis are fuſible with a moderate heat; they are ſo fixed that they can reſiſt during a ſufficient time the heat of ordinary vitrifications; and they act powerfully upon flints, ſands, and other vitrifiable ſtones. The proportion of alkali to ſand, in order to make good glaſs, is, from one to two parts of the former ingredient, and two parts of the latter.

Nitre produces in vitrification nearly the ſame effects as fixed alkalis, altho' it be a neutral ſalt, the alkali and acid of which are united together nearly as they are in common ſalt, which however does not produce in vitrification ſimilar effects. The remarkable difference in this reſpect betwixt theſe two ſalts, and betwixt the nitre and the vitriolic ſalts, muſt be attributed to the great affinity of nitrous acid to the inflammable principle; which affinity is ſo ſtrong, that when nitre is expoſed to fire in veſſels not perfectly cloſe, the acid quits its alkaline baſis to unite with the phlogiſton of combuſtible matters, even though theſe be not ſenſibly in contact with it. Hence nitre expoſed during a certain time to the action of a ſtrong fire, is gradually alkaliſed, and then becomes capable of diſſolving very effectually vitrifiable earth. This alkaliſation is produced ſo much more eaſily in moſt vitrifications, that the ingredients employed generally contain ſome inflammable matter. Common ſalt cannot be alkaliſed in this manner, becauſe it cannot be decompoſed by the contact of inflammable bodies, and therefore is not uſed in vitrifications: but as vitriolic acid has a ſtrong affinity with phlogiſton, we might be inclined to think, that vitriolic ſalts with baſis of fixed alkali, which alſo are never uſed in vitrification, might perhaps be employed along with ſand or other vitrifiable matters containing a larger proportion of phlogiſton than the ingredients now commonly uſed do: but I do not know that any ſufficiently accurate experiments have been made on this ſubject.

Fixed alkalis or nitre cannot be formed into tranſparent glaſs by being melted ſingly; becauſe theſe ſalts contain too little of the earthy principle; for they form

form true glaſſes when they are mixed with a ſufficient quantity of this principle, as with ſands and other earthy matters: but borax, ſedative ſalt, and the fuſible ſalt of urine, may be melted without any earthy addition, into tranſparent vitreous maſſes; and hence we may conclude, that theſe ſalts contain a larger portion of the earthy principle than nitre or fixed alkali. They nevertheleſs very powerfully promote the vitrification of other ſubſtances. Theſe ſalts are not employed in the manufacture of large quantities of glaſs, becauſe they are too dear. Borax is ſometimes uſed for making ſmall quantities of ſome particular kinds of fine glaſs.

Arſenic may be enumerated among vitrifying fluxes, as it is fuſible and vitreſcible ſingly, and is alſo capable of promoting the fuſion of vitrifiable earths; for which purpoſe it is frequently employed as an ingredient in vitreous compoſitions. As arſenic partakes both of the metallic and ſaline properties, it probably acts in vitrification both as a ſalt and as a metallic earth. The quantity therefore of arſenic neceſſary to promote vitrification, is intermediate betwixt the quantities of calx of lead and of ſaline ſubſtances that are neceſſary for that purpoſe. But we muſt obſerve, that as arſenic is very volatile, a great part of it eſcapes in vapors upon the firſt application of heat, and that the quantity remaining is always uncertain. Arſenic cannot well be employed as the ſole flux for vitrifiable earth. When we intend that a certain quantity of this matter ſhould remain in the compoſition of a glaſs, one of the beſt methods that can be uſed for this purpoſe, is at the ſame time to add nitre to the ingredients of this glaſs; becauſe the arſenic uniting with the alkaline baſis of the nitre forms the neutral arſenical ſalt, in which the arſenic is conſiderably fixed. But as this neutral arſenical ſalt is eaſily decompoſed by contact of phlogiſton, therefore no calx of lead or other ſubſtance containing the inflammable principle ought to be mixed with arſenic in the compoſition of glaſs. I have found by experience that this neutral arſenical ſalt is very difficultly manageable in vitrifications, not only for the reaſon now given, but alſo from the property it has of powerfully corroding and pervading crucibles and pots. In many mixtures I have found that it quitted the vitrifiable earth with which it was mixed, and acted upon the crucible, which it penetrated and diſſolved. Theſe experiments induce me to believe, that arſenic has a greater affinity with clays than with vitrifiable earths; which I propoſe hereafter to aſcertain further.

From Mr. Pott's experiments, chemiſts know, that vitrifiable, calcareous, and argillaceous earths, each of which are ſingly unfuſible, do reciprocally promote the fuſion of each other, when mixed together nearly in equal proportions, and expoſed to a very violent heat; and that from theſe mixtures matters perfectly vitrified are formed. But as we do not know the cauſe of this ſingular fuſibility, we cannot determine whether it is produced by a phlogiſtic or by a ſaline ſubſtance, or perhaps by both.

Glaſſes that contain no other fluxing ingredient than phlogiſtic matters or metallic earths, partake of the properties of theſe metallic earths; and alſo glaſſes that contain only ſaline fluxes partake of the properties of ſalts. The latter, or ſaline glaſſes, when pure and well proportioned are leſs heavy, leſs denſe, harder, whiter, more brilliant, more brittle, than the glaſſes containing calx of lead: and glaſſes containing both ſaline and metallic fluxes do alſo partake of the properties

perties of both these substances. In general, glasses too saline are soft, and easily susceptible of alteration by the action of air and water; especially those in which alkalis prevail; which latter glasses are also liable to be attacked by acids, as we evidently see from the properties of the vitrified matter that is made with an excess of alkali, for the preparation of *liquor of flints*. Glasses containing too much borax and arsenic, although at first very beautiful, do quickly tarnish and become opake when exposed to air.

From what we have said concerning the properties of fluxes, phlogistic or saline, we may know how to adjust the proportions of these to the sand, or powdered flints, for the various kinds of glass. Thus if we require a glass that is dense, fusible, and not saline, one part and a half of red lead or litharge may be mixed with one part of sand, and fused together. If equal parts of sand and of calx of lead be employed, a glass somewhat less dense and harder will be produced.

If a glass be required of very little density, only saline fluxes must be employed. A glass of this kind may be composed of six parts of salt of tartar, or of potash, or of purified soda, mixed with eight parts of sand or of flints; or of four parts of any of the above-mentioned alkalis, mixed with two parts of nitre or of borax, and eight parts of vitrifiable earth. These glasses must be left long in the fire for the reasons hereafter to be mentioned.

When a crystal-glass is required which shall be of an intermediate quality betwixt the metallic and saline glasses, it may be made from a mixture of one part of the above-mentioned salts, one part of calx of lead, and two parts of sand or other vitrifiable earth. By varying the proportions of these ingredients, many different kinds of glasses may be produced, each of which may be good, if the quantity of each of the fluxes employed be proportionable to its vitrifying power. Several good receipts for glass, and factitious crystal, may be found in *Neri's Art of Making Glass*, with *Notes by Merret and Kunckel*, to which work we refer for many interesting particulars. We shall however observe, that the proportions of the fluxes necessary to produce any required kind of glass cannot be precisely ascertained, for the following reasons.

First, the sands, flints, and other stones commonly employed for making of glass, are not all equally fusible. Thus the quartzose sand obtained by washing an earth found near Nevers, known to manufacturers of glass and of pottery by the name of *sand of Nevers*, may be almost entirely melted when exposed to a good vitrifying heat; and by a moderate heat its grains may be considerably rounded. I know some other hard stones, which in a violent fire are still more fusible, and convertible into an almost transparent glass without addition. The fusibility of these vitrescible stones is caused by some unknown heterogeneous matter united with them. These fusible sands and stones require a much less quantity of flux to promote their vitrification, than other sands or vitrifiable stones, which are much purer, and therefore more refractory.

Secondly, although the phlogistic and saline matters employed as fluxes in vitrification are sufficiently fixed to support the degree of fire necessary for the fusion of glass, they are nevertheless far from being so fixed as vitrifiable earth. The fire necessary for the perfect fusion of glass, is even sufficient to evaporate them entirely. Accordingly in glass-houses where the pots are uncovered, a

vapor

vapor or ſmoke continually riſes from their ſurface, which is nothing elſe than the ſaline and phlogiſtic fluxes in a ſtate of continual exhalation. Hence the longer glaſs remains melted in the fire, the harder and more difficultly fuſible it becomes, and the more it partakes of the properties of pure vitrifiable earth. Accordingly, even when a very hard glaſs is required, ſuch a quantity of flux ought to be added, as ſhall at firſt promote a perfect fuſion; and this fuſion ought to be continued a long time till a conſiderable quantity of the flux is gradually diſſipated, and till the glaſs has acquired the requiſite degree of hardneſs, provided that the fire be ſufficiently ſtrong to maintain the fuſion notwithſtanding the loſs of flux. From theſe obſervations it appears, that we cannot preciſely aſcertain the proportion of flux to vitrifiable earth, unleſs we knew the fuſibility of the ſand to be employed, and the degree of heat which can be excited in the furnace.

The ſaline fluxes, and eſpecially the fixed alkalis employed in vitrification, are generally rendered impure by a mixture of ſeveral heterogeneous matters, and eſpecially by neutral ſalts not vitrifiable, and by a certain quantity of inflammable principle. In manufactories of bottles and other common glaſs, the alkalis employed are not previouſly purified, but are even mixed with the earth of the aſhes of the burnt plants, which earth is alſo much diſpoſed to vitrification. Accordingly, to make glaſs of this kind, ſand is mixed with common wood-aſhes, ſometimes even with thoſe which have been lixiviated, together with ſome unpurified potaſh, ſoda or kelp; and from this mixture a brown, duſky, not very tranſparent glaſs is produced, which is preferred in common ſale for wine bottles to clearer and more tranſparent glaſs. But when a fine, white, and very tranſparent glaſs is required, the alkali muſt be perfectly purified from all heterogeneous matter, by lixiviation and calcination. *See the article* ALKALI (FIXED).

As a too large quantity of the inflammable principle is the chief cauſe of the colors and of the opacity of glaſs, when a perfectly colorleſs and tranſparent glaſs is required, not only the alkalis muſt be deprived of all their ſuperabundant phlogiſton, but alſo the ſands or flints employed muſt be purified from any of this principle which they may contain. The method uſed for this purpoſe is by mixing together the due proportions of ſands and ſalts, by expoſing this mixture during a conſiderable time to a red heat, not intenſe enough to melt it. By this calcination, the phlogiſton of theſe matters is burnt and diſſipated, all color is deſtroyed, and the glaſs produced is alſo more clear and brilliant. This firſt mixture of materials of glaſs, when calcined, is called *the fritt*; and this fritt is uſed in large manufactories not only for the finer glaſs, but alſo for the common brown glaſs; not with an intention to render this latter kind of glaſs colorleſs, but becauſe during this calcination, the ſalts and earth begin to act upon each other, and to incorporate in a certain degree; by which a great part of the efferveſcence and ſwelling occaſioned by the reaction of theſe matters, which happen when they are at once expoſed to a melting heat, are avoided. Accordingly when matters not previouſly fritted are employed in ſmall experiments, the heat muſt be applied gradually; otherwiſe they ſo ſwell, that frequently the greateſt part of the mixture runs over the crucible.

The due degree of heat is an eſſential point in making of glaſs; it ought not only to be very ſtrong, but alſo maintained during a long time. In great

manufactories,

manufactories, the glaſs is kept fuſed during ten or twelve hours before it is taken out of the pots. Accordingly their glaſs is always more perfect than that which is haſtily made in ſmall quantity in two or three hours. Good glaſs, although kept in fuſion in a very great heat, is not perfectly liquid. It is always ſomewhat thick, and when taken from the crucible, it may be drawn out into fine wire or threads; which ſhews that it has a certain conſiſtence and a very ſenſible tenacity when it is red-hot. It is not tranſparent, while it remains red-hot, not even when it has become perfectly hard. Another remarkable circumſtance is, that glaſs which is ſo brittle when it is cold and tranſparent, is very ductile when it is ſo heated as to be opake. We might be induced to believe, that the diſengaged fire with which the glaſs is filled when it is red-hot, produces upon it the ſame effect that phlogiſton, or combined fire, produces upon metals. The ductility of red-hot glaſs is very uſeful; for by its means all imaginable ſhapes may be given to glaſs, and numberleſs veſſels and utenſils may be eaſily formed of it

As ſoon as glaſs-veſſels have received their intended form, they muſt be cooled very gradually, otherwiſe they would have no ſolidity, and would be of little uſe, as they would be liable to be broken by the ſmalleſt ſtroke, or by a ſlight change of heat and cold. This inconvenience is prevented in glaſs-houſes by carrying the glaſs veſſels as ſoon as they are formed, and while yet red-hot, into an oven too little heated to deſtroy their form, but in which they may be very gradually cooled. This is called *annealing* the glaſs.

Notwithſtanding all the care taken in the manufactories of the finer kinds of glaſs, as cryſtal-glaſs and plate-glaſs, to make them perfectly good, they are nevertheleſs ſeldom found quite free from faults. The principal faults in glaſs are, colors, bubbles, and veins. The colors which generally hurt glaſs, eſpecially that kind which contains ſaline fluxes, are ſhades of green, olive, and blue. Theſe colors are deſtroyed by *manganeſe*, which being added in ſmall quantities, clears the glaſs, and is therefore ſometimes called by artiſts, *the ſoap of glaſs*. This effect of manganeſe cannot eaſily be explained, for it has the property of tinging glaſs with a purple color. Mr. Montamy, in his *Traité des Couleurs pour la Peinture en Email*, has a very fine and ingenious thought upon this ſubject, which is, that the manganeſe deſtroys the above-mentioned colors, by adding to theſe a purple tinge, and by the mixture producing a blackiſh-brown color; and that as blackneſs is cauſed merely by an abſorption of the rays of light, therefore the blackiſh tinge given to the glaſs by the above mixture of colors, prevents the reflection of ſo many rays, and thus renders the glaſs leſs colored than before. The cauſes of the bubbles and of the veins in all glaſs, even when moſt carefully prepared, and the methods of preventing theſe faults are little known. No reſearches have been made upon this ſubject, by any chemiſt excepting by Mr. D'Antic, whoſe experiments are publiſhed in the Memoirs of the Academy. But however intereſting theſe may be, this matter requires further examination. As the veins of glaſs, unleſs they be conſiderable, are ſeldom very perceptible in the finer kinds of glaſs when well compounded, and carefully made, they have therefore been hitherto neglected. Nevertheleſs we ought to inform thoſe who are intereſted in the progreſs of arts and ſciences, that ſince the important diſcovery of achromatic teleſcopes

has

has been made, the correction of this fault in glass deserves attention. We need only inform those who would attempt this improvement of glass, that the object-glass of these telescopes is composed of several glasses of different degrees of density; and that the effect of this composition of different glasses is (supposing them at the same time to have the due curvatures), that telescopes may be made, which do not exhibit irises when looked through, which are therefore infinitely preferable to ordinary telescopes, and from which astronomy may receive much advancement.

Some great geometers have determined the density and the curvature that these object-glasses ought to have. But in vain have Euler, Clairaut, and D'Alembert illustrated this part of dioptrics by means of the most sublime theory, unless glasses can be made which shall be capable of producing the effects required. No certain and constant method is yet known for making crystal-glass for this purpose. A celebrated English optician, Mr. Dollond, who has himself had a considerable share in the discovery of these new telescopes, does indeed make them very good (*p*). But our opticians, who procure from England the same glass that is employed by the English opticians, affirm that this glass is very faulty; and that amongst a large quantity, some pieces only can be found fit for the purpose: hence we find that it is not constantly made good in the English glass-houses.

A certain method therefore of making such a crystal glass as is required, still remains to be discovered. Two kinds of glass are required for the object-glass of achromatic telescopes. One of these is a light crystal-glass, made with saline fluxes, like the French mirror-glass.

Good pieces of this kind of glass may be easily found. The other kind of glass is a denser crystal-glass, and therefore contains some calx of lead in its composition. Such is the English flint-glass. The density of this glass ought to be such, that a cubic inch shall weigh fourteen hundred grains. A perfect

(*p*) The indistinctness of the images seen through common telescopes proceeds chiefly from this cause, that some of the colored rays of light are refracted more in passing through glass, or any refracting medium, than the others, and do therefore produce prismatic colors. The late ingenious Mr. Dollond found, that this difference of refrangibility of the colored rays was much greater when the rays passed through some kinds of glass, as crown-glass, than through others, as flint-glass. By adding therefore to the convex object lens of telescopes (which was made of crown-glass) a concave lens made of flint-glass, the curvature of which was not sufficient to destroy the whole convergency of rays of light produced by the convex lens, he counteracted the error proceeding from the different refraction of the colored rays in passing through the convex lens, and, by thus uniting these several rays, formed one distinct image. This power of different kinds of glass, by which they refract differently the colored rays is not proportionable to the density of the glass; although calx of lead added to glass singularly encreases this difference of refraction. The author of the Dictionary says, that Mr. Dollond had a great share in this discovery. He was the first person who attempted or who executed this improvement. We may indeed observe, that long before, in the year 1713, Dr. David Gregory, the celebrated Professor of Astronomy at Oxford, did suggest, (in his *Catoptricæ et Dioptricæ Sphaericæ Elementa*) that by compounding the object lens of a dioptric telescope of several media of different refractive powers, the image might be rendered more distinct, in the same manner (says he) as it is done by the compounded media of the eyes of animals.

glass

glaſs of this kind cannot be obtained without great difficulty. I have been aſſured by ſome intelligent perſons, who have conſidered this ſubject of achromatic teleſcopes, that the qualities eſſentially requiſite in this glaſs were, that it ſhould be very tranſparent, and perfectly free from veins, to which it is very liable; and that a ſlight tinge of yellow and even a few bubbles were not very injurious. I have made many experiments to obtain a cryſtal glaſs free from veins, but have met with great difficulties. The veins are undulated, like thoſe which appear when two liquors of different denſities, as water and ſpirit of wine, are added together, and before they are well mixed. This appearance ſhews, that ſomething ſimilar happens in the making of glaſs. I endeavored to correct this fault by a very careful mixture, and by a compleat fuſion. But I confeſs, that although I have expoſed theſe glaſſes to very violent and long continued fires, and have ſeveral times pulveriſed and ground them, and repeated the fuſion, I have not been able to procure any perfectly free from veins. I have been prevented by other neceſſary occupations from continuing my experiments on this ſubject. But although thoſe which I have made ſufficiently ſhew the difficulty of making glaſs of the required denſity, and which ſhall be perfectly free from veins, this difficulty nevertheleſs does not appear unſurmountable; and I do not doubt but that by patiently proſecuting this inquiry, we may arrive at the deſired ſucceſs.

We ſhall obſerve, in concluding this article, that ſeveral cauſes leſſen or entirely prevent the tranſparency of glaſs, which is one of its moſt neceſſary qualities. As we cannot melt vitrifiable earth into tranſparent maſſes but by means of fluxes, and a ſufficiently ſtrong and long-continued heat, therefore when the vitreous mixture contains too little flux, or is expoſed to too little heat, ſome parts of the vitrifiable earth cannot be entirely fuſed, and therefore injure more or leſs, according to their quantity, the tranſparency of the glaſs. The ſame fault may be perceived in glaſs, when it contains ſome earthy matter not ſuſceptible of the action of fluxes, as vitrifiable earth is; ſuch as, for inſtance, moſt metallic earths that are too much dephlogiſticated, particularly the earth of tin. Accordingly, theſe earths are employed to make opake or ſemi-tranſparent glaſſes, as enamels, artificial opals, and other ſuch ſtones. Another remark may be made concerning the tranſparency of ſome kinds of glaſs, that it is deſtructible by a too long expoſure to violent heat. As all fluxes, phlogiſtic or ſaline, are much leſs fixed than vitrifiable earth; and as ſome fluxes are leſs fixed than others, or leſs capable of becoming fixed by being mixed with vitrifiable earth; the cauſe therefore of the loſs of tranſparency which ſome glaſſes ſuffer by a too violent fire, is, that a part of their flux is diſſipated, ſo that theſe glaſſes are decompoſed, and that they contain ſo much earth that the flux is incapable of keeping them compleatly fuſed. I have obſerved that glaſſes formed by a mixture of argillaceous, and gypſeous or calcareous earths are more liable than any others to this loſs of tranſparency. *See* ALKALI, EARTH, FURNACES, *and ſeveral other articles relating to vitrification.*

DCCXIX. VITRIOL. This name is particularly applied to three neutral vitriolic ſalts with metallic baſes. Theſe ſalts are, 1. The combination of vitriolic acid with iron, called *martial vitriol*, *Engliſh vitriol*, *green vitriol*, or *green copperas*. 2. The ſalt reſulting from the union of the ſame acid with copper, called *vitriol of copper*, *blue vitriol*, *Cyprian vitriol*, or *blue copperas*.

3. The

3. The salt composed of vitriolic acid with zinc, called *vitriol of zinc*, *white vitriol*, *white copperas*, and *Goslar vitriol*.

We have observed under the articles *vitriolic acid* and *salts*, that the name *vitriol* ought to be applied to all vitriolic salts with metallic basis. Thus, for instance, the salt composed of vitriolic acid and gold may be called *vitriol of gold*; and the salt formed by the union of this acid with silver may be called *vitriol of silver*, or *lunar vitriol*. Perhaps all vitriolic salts might be conveniently comprehended under the general name *vitriol*. The properties of vitriolic salts are mentioned at the articles, ACID (VITRIOLIC), ALKALIS, EARTH (CALCAREOUS), SALTS, SELENITES, GYPSUM, ALABASTER, SPAR, SMELTING *of* ORES, *and of the several metallic substances*.

DCCXX. UMBER. (q)

DCCXXI. VOLATILITY. Volatility is a property that many bodies have of being reduced into light vapors, which exhale when they are exposed to the action of fire. This quality is opposed to *fixity*. The cause of it is the greater or less *dilatability* which bodies have when exposed to fire. Perhaps every body is, rigorously speaking, volatile: but as there are some the volatility of which can be only rendered sensible by the action of a fire much more violent than any which we can produce, we consider these bodies as being fixed, or not volatile. *See* FIRE *and* FIXITY.

DCCXXII. URINE. As urine is an excrementitious animal liquor, it contains only such principles as are useless or hurtful to the animal economy; and is accordingly found to be nothing but a lixivium of different saline substances, which cannot enter into the composition of an animal body, together with a quantity, not very considerable, of a saponaceous, extractive, and very putrescent matter. In urine we find none of the gelatinous substance that is contained so copiously in other animal liquors that are not excrementitious; for this gelatinous substance, as we have said under the article JELLY, is the principal constituent, nutritive, and reparative part of animal bodies, and could not therefore without some considerable fault or disorder in the animal economy be rejected with any excrementitious matter. The urine of healthy animals is therefore nothing but a serous saline liquor, that may be entirely evaporated, without shewing any gelatinous matter.

The fresh urine of healthy animals is transparent, and something yellowish or citron-colored, has a slight smell, a saline nauseous taste, and does not change the color of syrup of violets to a red or to a green: but this liquor varies considerably when the animal economy, and especially the digestive organs are disturbed. Accordingly, physicians carefully observe the urine of their patients; but although they often receive much assistance from such observation, it is a dangerous error that quacks lead many ignorant persons into, to believe, that by the mere inspection of urine all diseases may be discovered.

(q) UMBER. Umber is a very light, dusky-colored earth, which is somewhat inflammable, and emits a strong smell when it is burnt. By calcination it is changed, according to Wallerius, to a white earth, and, according to Linnæus, to a red earth; whence the latter author conjectures that it contains some iron. It seems not to have been much examined.

Phyſicians, who have paſſed their lives in an attentive obſervation of the ſigns of diſeaſes, are too ſenſible of the inſufficiency of every aid to decide certainly concerning the nature of many diſeaſes. But this reflection ought to be a motive to inquire into the various changes that urine undergoes in different ſtates of the body, more accurately than has been hitherto done, eſpecially as the improvements daily made in chemiſtry may give us hopes of throwing more and more light upon this and other intereſting ſubjects.

The qualities of urine are very apt to vary conſiderably, even without any very perceptible derangement of the animal economy. For inſtance, it is ſometimes much more copious than at other times. This difference of the quantity of urine has been obſerved to depend much on the quantity of perſpiration and of ſweat that have been exſuded at the ſame time; for the nature of theſe fluids is very ſimilar to that of urine. Generally, when the urine is in ſmall quantity, it is deeper colored; and reciprocally.

The urine of perſons afflicted with hyſterical and melancholical ſpaſms is frequently copious, limpid, and purely watery or ſerous, without color or ſmell. This urine is called *crude urine*. Theſe ſame perſons do alſo frequently diſcharge urine in ſmall quantity, that is high-colored, that has a ſtrong ſmell, and that quickly becomes turbid when expoſed to cold. We may obſerve, that the ſediment which renders this urine turbid may be again rediſſolved by more freſh and warm urine, and is therefore of a ſaline nature.

Certain odoriferous ſubſtances, taken internally, as turpentine, aſparagus, and others, are well known to communicate quickly their ſmell to urine, even in perfect health: but I have alſo ſeen perſons ſubject to pains of the head and to bad digeſtion, proceeding from a melancholic or hyſterical temperament, who diſcharged urine, in which I could evidently perceive the ſmell of coffee, ſpices, onions, fruits, roots, and even of broth, and other aliments. The urine of theſe perſons was habitually acid, reddened ſyrup of violets and blue paper, when it was recent, and eſpecially after eating fruits and roots, or drinking even a very ſmall quantity of wine.

From theſe two latter obſervations we may perceive, that urine depends much on the ſtate of digeſtion, the faults of which may therefore be diſcovered by examining that liquor.

Urine is ſtrongly diſpoſed to putrefaction. In ten or twelve hours, when the weather is warm, it acquires a ſtrong ſmell; and in great heats, this ſmell may be perceived in five or ſix hours. The beginning of the putrefaction of this liquor may be perceived by a putrid, diſagreeable, but not pungent ſmell. The ſmell afterwards becomes pungent, and diſcovers a volatile alkali, which is very copiouſly diſengaged in the putrefaction of this liquor. Although the diſagreeable ſmell that is perceived at firſt in urine beginning to putrefy has not the pungency of volatile alkali, it nevertheleſs ſeems to be produced by this ſalt; for by mixing any acid with urine in this ſtate, its fetid ſmell is immediately deſtroyed. By the ſame means alſo the ſmell of veſſels in which urine has been contained may be deſtroyed. On the contrary, by mixing ſome fixed alkali or quicklime with freſh urine, a pungent ſmell of volatile alkali and of putrid urine is inſtantly produced. As in ſo ſhort a time no real putrefaction can happen, we muſt attribute the diſcharge of volatile alkali in this experiment to

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a decompoſition of a ſal ammoniac, which is contained in the freſheſt urine, as we ſhall ſoon ſhew.

If the freſh urine of a healthy perſon be diſtilled in cloſe veſſels, nothing is obtained from it with the heat of boiling water, but a pure phlegm with a ſlightly nauſeous ſmell. This phlegm is generally $\frac{7}{8}$ parts or more of the whole urine; but the quantity of this and of the other principles of urine are very various.

As nothing but phlegm is ſeparated at firſt in this diſtillation, when therefore urine is to be analyſed, the operation may be accelerated and ſimplified by evaporating it over the fire in an open veſſel. We may then obſerve, that while the phlegm of the urine is evaporated, the remaining liquor becomes turbid, and depoſites a certain quantity of matter which is almoſt entirely earthy. The quantity of this earth varies alſo according to the nature of the urine. It deſerves a particular examination. The obſervations of Mr. Heriſſant, Phyſician of the Faculty of Paris, and Member of the Academy of Sciences, concerning the urine of ſeveral perſons afflicted with diſeaſes in which the bones were affected and waſted *(See Memoirs of the Academy for the year* 1758); and thoſe alſo of Mr. Morand, of the ſame Faculty, and Member of the ſame Academy, concerning the urine of a woman whoſe bones were entirely ſoftened by the loſs of their earthy matter, which was found to contain a conſiderable quantity of earthy ſediment; ſhew, that the earthy ſediment of urine, which is firſt depoſited by evaporation, is partly at leaſt of the ſame kind as the earth of bones; and that in a healthy ſtate, nature throws off by the urinary paſſages all the earthy matter that is not required for the encreaſe or reparation of the bones. This earthy ſediment appears alſo in putrid urine.

While the urine evaporates, the remaining part of it acquires a more and more deep brown color, by the approximation of the ſaponaceous extractive parts which it contains. When, by evaporation, it has acquired the conſiſtence of a clear ſyrup, or of freſh cream of milk, it ought to be put in a cool place, that the ſeveral neutral ſalts which it contains may be cryſtallized. The firſt cryſtals that are obtained are a particular kind of ſalt known to chemiſts by the names, *native* or *eſſential ſalt of urine*, *fuſible ſalt of urine*, *phoſphoric ſalt*, and *microcoſmic ſalt*. This ſalt contains the acid proper for making phoſphorus. Some part of this ſalt has a baſis of volatile alkali, and is therefore a kind of ammoniacal ſalt; and the reſt has a baſis of fixed alkali. *See* SALT (FUSIBLE) *of* URINE, *and* PHOSPHORUS *of* KUNCKEL. When the urine contains any ſalts that are more cryſtallizable or leſs ſoluble than the fuſible ſalt, as it frequently does, ſuch as ſelenites, vitriolated tartar, and others, theſe are firſt cryſtallized, eſpecially if they be in conſiderable quantity. *See* CRYSTALLIZATION.

By alternately evaporating and cooling the liquor, the other leſs cryſtallizable ſalts, ſuch as common ſalt, a great quantity of which urine generally contains, may be ſeparated. In the urine of different animals all the neutral ſalts are generally found which they have taken, either along with their aliments or otherwiſe; becauſe theſe ſalts, not being uſeful in the compoſition of animal matters, after having circulated ſome time in the blood-veſſels, are carried off, unchanged, along with the urine.

After all the neutral ſalts have been obtained from urine, nothing remains but a brown, ſaponaceous, extractive matter, which forms a kind of mother-

water. This matter yields, with a naked and graduated fire, a confiderable quantity of volatile alkali, both fluid and concrete, together with fome fetid animal oil. With the utmoft violence of fire, a fmall quantity of phofphorus may alfo be obtained; and a little common falt may be feparated from the refiduous coal. This phofphorus is produced by a little fufible falt which was not feparated by cryftallization, but remained, together with the above-mentioned fmall quantity of common falt, diffolved in the liquor.

From this analyfis of urine we may perceive, that it is compofed of a large portion of pure water, in which is diffolved a confiderable quantity of earthy matter, that forms the fediment of urine; of two phofphoric falts, one of which is ammoniacal, and the other has a bafis of fixed alkali; of common falt; and, laftly, of a faline, faponaceous matter, which contains a combined oil. In urine no gelatinous matter nor uncombined oil are found.

Such is the ftate of our prefent knowledge concerning the nature and principles of urine. It certainly is capable of receiving much addition from future inquiries, by which medicine might be much improved; but we muft, at the fame time, confefs, that we cannot receive all the knowledge we wifh upon this fubject without very long and laborious operations. The moft important point to be known is the compofition and proportions of the feveral conftituent parts of urine: but, as we have already remarked, thefe are very variable, according to the ftate of health or of ficknefs, to the differences of conftitutions, aliments, exercifes, difeafes, medicines, and perhaps even to the variations of the atmofphere. A knowledge of the differences of the urine in all thefe feveral circumftances is very important, but can only be acquired by a long and zealous obfervation of thofe phyficians who are inftructed in the feveral fciences relative to their profeffion.

DCCXXIII.

W.

DCCXXIII. WAND (DIVINING). The divining wand is an instrument, by means of which many persons have formerly pretended, and some do now pretend, to discover under what parts of the earth metals, treasures, ores, water, salt, &c. lie hid, without digging the ground. They say, this discovery may be made by a person holding the wand horizontally, and by walking along in places where these matters are expected; and that when he arrives at a place under which any of the above-mentioned matters lie, the wand will be forcibly inclined towards that place: but that this experiment should succeed, much faith seems to be required in the person who holds the wand, or rather in the spectators. We may easily perceive, that the power of this wand is a chimera, which owes its reputation to avarice, to ignorance, and to credulity.

The famous Father Kircher, in his *Mundus Subterraneus*, in which many interesting particulars are found concerning mines, justly derides these superstitious practices, and denies, from his own experience, the truth of the assertions concerning them. He seems, however, to have some faith in sympathies, and proposes even new divining wands of his own invention; the effects of which, though more dependant on physical causes, are not however more certain. He believes, for instance, that a wand, one end of which should be made of sal gem, and the other of wood, being suspended and balanced above a mine of salt, would be inclined towards the ground; and he supports his opinion by an experiment. This experiment consists in evaporating over the fire a solution of sal gem, below the wand, which is by this means really made to incline. We need not be deeply learned in chemistry to discover, that the wand would have inclined in the same manner if Father Kircher had evaporated pure water instead of a solution of sal gem; because the water would have equally well attached itself to the saline end of the wand; consequently this experiment proves nothing.

The same author proposes also to discover mines of mercury by employing a wand, one end of which is made of gold, and the other of wood, in hopes that

that the emanations of the mercury would attach themſelves to the gold rather than to the wood, and would make it incline downwards. But this effect certainly cannot be produced unleſs the mercury was evaporating; for which purpoſe two conditions are neceſſary: 1. The mercury muſt be in a native metallic ſtate, and not mineraliſed, as it is in cinnabar; and, 2. It muſt alſo be expoſed to the heat of ſome ſubterranean fire, by which it is volatiliſed and ſublimed, the ordinary heat of the earth being far too little for this purpoſe. This ſecond phyſical or chemical divining wand propoſed by Father Kircher is therefore no better than the former; and probably the ſame judgment may be paſt upon all other wands made upon the ſame principles, and in imitation of theſe. Laſtly, the ſame author poſitively affirms, that he hung and balanced a wand, one half of which was made of alder-tree, and the other half of ſome wood that has no ſympathy with water, over a ſubterranean water, and that he obſerved the end of the wand incline towards the earth.

DCCXXIV. WATER. Water, perfectly pure, (for of ſuch only we treat in this article) is a tranſparent body, without color, without ſmell, and without taſte.

Water is very volatile, and ſo very fuſible, that it is conſtantly liquid with a leſs degree of heat than is requiſite for vegetation: hence it is generally conſidered as a liquid. But when it is expoſed to a leſs degree of heat, it becomes ſolid, like all other bodies naturally ſolid, which reſume their ſolidity when they are no longer expoſed to a heat ſufficient to keep them in fuſion.

When water, that is expoſed to a degree of cold ſufficient to render it ſolid, paſſes from a fluid to a ſolid ſtate, this change is called the *congelation* or *freezing of water*; and the water thus rendered ſolid is called *ice*.

When water is frozen with all the circumſtances neceſſary for the free arrangement of the integrant particles of bodies (which circumſtances are explained under the article CRYSTALLIZATION), it aſſumes determinate and regular forms. M. de Mairan, in his excellent Treatiſe on Ice, has determined, that theſe regularly formed maſſes of frozen water are like needles croſſing each other, or rather infixed into each other, ſo as always to form two angles, one of which is equal to ſixty degrees, and the other equal to a hundred and twenty degrees.

This regularity in the congelation or cryſtallization of water ſhews, that it is a body not much compounded. We ſhall ſoon ſee that it is one of the ſimpleſt of all known bodies.

Water is not compreſſible. This truth is aſcertained by a famous experiment, which conſiſts in including water in a hollow ſphere of metal hermetically cloſed, and in expoſing this ſphere to a very ſtrong compreſſion, by which means the water is forced through the pores of this metallic ſphere rather than ſuffer any compreſſion. *(r)*

(r) The validity of the inferences drawn from this experiment, called the *Florentine experiment*, has been juſtly queſtioned. An ingenious philoſopher, Mr. Canton, has proved, by experiments ſhewn to the Royal Society, that water is actually compreſſed by the weight of the atmoſphere. The diminution of ſize that water ſuffers when it paſſes from a greater to a leſs degree of heat, till it begins to freeze, ſufficiently ſhews, that the integrant parts of this fluid are, like thoſe of all other known ſubſtances, capable of approximation.

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The ſpecific gravity of water, compared with that of air in a temperature intermediate betwixt the greateſt ſummer heats and the greateſt cold of winter, has been determined by the beſt experimental philoſophers to be nearly as 850 to 1; that is to ſay, that any given bulk of water is 850 times heavier than an equal bulk of air.

We have ſaid above, that water is a very volatile body. It is entirely reduced into vapors and diſſipated, when it is expoſed to the fire, and is not confined.

When water is heated in an open veſſel, and is unconfined, it has been obſerved to acquire no more than a certain determinate degree of heat, whatever be the intenſity of the fire to which it is expoſed; which greateſt degree of heat is that which it has when it boils quickly. This degree of heat, and alſo that degree at which water begins to freeze, are fixed and determinate, and are therefore very uſeful in many chemical and phyſical experiments. By means of theſe fixed points of heat, we have been enabled to conſtruct thermometers, which may always be compared one with another; and we have alſo been enabled to apply preciſe and determinate degrees of heat, which are neceſſary in many chemical operations. *See* Bath (Water).

Some philoſophers have ſaid, that the property which water and ſome other bodies have, of acquiring only a determinate degree of heat, proceeds from the rarefaction cauſed by this degree of heat, by which means the fire penetrates them freely and without any reſiſtance. *See* Fire. But this opinion is erroneous. The cauſe of this phenomenon evidently is, that water being volatile, is reduced into vapors which are conſtantly exhaled and removed from the fire, the action of which they elude as ſoon as they ſuffer a certain degree of heat, as may be proved by the following conſiderations.

Firſt, none but volatile bodies have this property; bodies abſolutely fixed being capable of acquiring indefinite degrees of heat: hence the more volatile a body is, the leſs heat it can acquire, and reciprocally; or, to ſpeak geometrically, the degrees of heat which bodies expoſed to the action of fire, and unconfined, can acquire, are inverſely as their volatility, and conſequently directly as their fixity.

Secondly, when water and all volatile bodies are expoſed to the action of fire, and ſo confined that they cannot freely evaporate or elude that action, they are then capable of acquiring a degree of heat that is much more conſiderable, is indeterminate, or rather proportionable to the force with which ty are confined, and prevented from evaporating.

We have an obvious example of this in the effects of *Papin's Digeſter*. Water being confined in this veſſel ſo that it cannot evaporate, is capable of acquiring a degree of heat much greater than that with which it boils in open air, and even ſufficient to make it red hot.

Upon this ſubject we muſt obſerve, that when water, or other volatile bodies, are thus expoſed to a greater degree of heat than is ſuited to their volatility, they are in a violent ſtate; and are therefore apt to break any veſſels that confine them, with an exploſion ſo much more violent, as they are more ſtrongly compreſſed, and are expoſed to a more violent and more ſuddenly applied heat.

Hence we may conceive why water expoſed to heat too ſuddenly to allow it to evaporate gradually occaſions terrible exploſions; as, for inſtance, when

water

water is thrown upon very hot oil, or when a melted and red-hot metal is poured into a moist vessel.

We ought to observe upon the subject of these explosions, that they only happen when the volatile bodies are in an aggregate state, or are combined with other volatile bodies; for the most volatile substances, when combined with fixed bodies, may be exposed to the most violent heat without producing these effects. Thus water, when combined with quicklime, with fixed alkali, and other salts, may be suddenly exposed to a red-heat without danger of explosion.

Water seems to be unalterable and indestructible: at least, no experiment is hitherto known from which we may infer that water may be decomposed. With whatever substances it may be combined, when separated from these and sufficiently purified, it is always found to be the same as before. When it is distilled singly, or mixed with some other substance, its nature and essential properties still remain unchanged.

Some philosophers, as Boyle, and especially Mr. Margraaf, having very frequently distilled the same water, obtained at each operation a small portion of earth; but the water which was distilled remained always essentially the same. The small quantity of earth separated from the water ought to be considered as extraneous to it.

The famous experiment of Van Helmont, which has since his time been more carefully repeated by others, and which consists in making trees and plants grow merely by means of water, does not prove, as some have supposed, that pure water is convertible into earth, salts, oil, and the other principles of vegetables; because water not only contains a small quantity of earth mixed with it, but also the air alone is the vehicle of a considerable quantity of these principles, or of such as are capable of producing them.

Water therefore appears to be a body simple and unalterable: at least, chemists, not having any means of decomposing it, may consider it as such. They have accordingly classed it amongst the *elements* or primary principles. *See* ELEMENTS *and* PRINCIPLE.

Many experiments and chemical analyses shew, that water enters as a principle in the combination of many compound bodies, such as all saline and oily substances (*See* SALT *and* OIL); and consequently that it is a part of all vegetable and animal matters, and of all the saline parts of minerals. Several stones even, in which no saline matter appears, as calcareous stones, contain a certain quantity of water, which seems to be in a state of combination. *See* EARTH (CALCAREOUS) *and* QUICKLIME. But hitherto no experiment shews, that water enters as a principle into the combination of *metallic matters*, or even into that of *vitrescible stones. See these words.*

Water dissolves many bodies. It seems to be capable of dissolving a certain quantity of air; for all natural water being placed under an exhausted receiver emits many air-bubbles; and, according to Mr. Musschenbroek, the water from which air has been thus separated, is capable of resuming the same quantity of air; that is to say, if a small quantity of air be introduced into this water, it will not form a bubble, as it would with water already saturated with air, but incorporates with the water, and entirely disappears.

Water seems also capable of dissolving a small quantity of calcareous earth; for the most limpid, clear water being distilled, always deposites some part of this

this earth. Some very limpid ſpring waters contain ſo much calcareous earth, that they depoſite a ſediment which encruſts any bodies that happen to be immerſed in them. Theſe waters become thus impregnated by flowing through large quantities of calcareous earth. Such are the waters of D'Arcueil near Paris, and all thoſe which form incruſtations, petrefactions, and ſtalactites. This earth does not ſeem to adhere very ſtrongly to the parts of water, eſpecially when it is in conſiderable quantity. It ſeems to be in an intermediate ſtate betwixt that of ſimple mixture and of perfect combination with the water.

Metallic matters, excepting the perfect metals, are acted upon by water, but eſpecially by the vapor of water, together with the concurrence of air. It converts their ſurfaces into ruſt, and deprives them of part of their inflammable principle. It does not appear to be diſpoſed to unite with the principle of inflammability; for all the bodies that are abundantly furniſhed with this principle reſiſt the action of water, unleſs they have alſo ſome other principle that may ſerve as an intermediate ſubſtance for this union.

But, of all known bodies, ſaline ſubſtances are moſt eaſily and copiouſly ſoluble in water. A ſtrong affinity is obſervable between this element and all ſaline ſubſtances; ſo that we may ſay in general, that all ſalts are ſoluble in water; that every body truly ſoluble in water is of a ſaline nature; and that no other body can be diſſolved in water but by means of a ſaline ſubſtance. *See* Salts.

Spirit of wine, and all ardent ſpirits of the ſame kind, may be diſſolved in water in all proportions. *See* Spirit (Ardent).

The ſpiritus rector of vegetable and animal ſubſtances, and moſt of the very thin and very volatile fluids, called *gas*, are ſoluble in water. *See theſe words.*

Ethereal liquors, as vitriolic, nitrous, marine, and acetous ethers, are ſoluble in water, but only in certain proportions. *See* Ether.

Water diſſolves the moſt ſubtle and volatile part of any oils, as Mr. Beaumé has obſerved. *See* Oils.

Compounds, formed of any oily matters united with ſaline matters, (to which compounds we ought to give the general name of *ſoap*, or *ſaponaceous ſubſtance*) are ſoluble in water, ſo much more eaſily and copiouſly as their ſaline principle is in greater quantity, and more diſengaged or unfolded. *See* Soap.

Laſtly, water is the proper ſolvent of all mucilaginous, gummy, and gelatinous matters; which matters are compoſed of ſaline, oily, and earthy principles. *See* Gum.

We may eaſily perceive from what has been ſaid concerning the properties of water, that it muſt be very uſeful in many chemical operations: but as it diſſolves ſo many bodies, it can ſeldom be found naturally free from heterogeneous matter, or perfectly pure. The waters of rivers and of ſprings, however limpid they may be, always contain a certain quantity of earth, which is in the intermediate ſtate above-mentioned, between a ſimple interpoſition of parts, and a true ſolution. The beſt waters of this kind are thoſe which flow through ſands, gritt-ſtone, and other vitrifiable matters; becauſe vitrifiable earth is leaſt capable of being attacked by water.

The waters of many springs and rivers contain more or less of a gypseous or selenitic substance really dissolved; for as water is capable of dissolving these matters, and often flows through grounds containing them, it must dissolve a certain quantity of them, and even as much as saturates it. Waters impregnated with selenites are unfit for chemical operations, for being drank, for dissolving soap, or for boiling leguminous vegetables. They are a kind of *mineral waters*, and are called *crude* or *hard waters*. *See these words.*

Rain or snow-waters, properly collected, that is, not in stormy weather, after it has already rained or snowed some time, in open air, and far from the habitations of men, and received in earthen-ware vessels, are the best and the purest of all native waters. They are sufficiently pure for most chemical operations, because they have been purified by a kind of natural distillation: but for greater exactness, and because these waters are not always procurable, distilled water is generally employed in chemical operations. *See* WATER (DISTILLED).

(*s*) Native water is seldom, if ever, found perfectly pure. The *waters* that *flow within*, or *upon the surface of*, *the earth* contain various earthy, saline, metallic, vegetable or animal particles, according to the substances over or through which they pass. *Rain* and *snow-waters* are much purer than those, although they also contain whatever floats in the air, or has been exhaled along with the watery vapors. Mr. Margraaf has very accurately analysed some rain and snow-waters, and found that they contained a calcareous earth united with nitrous and marine acids, the rain possessing more of the former, and the snow more of the latter acid, together with some mucilaginous, oily, and ferruginous particles. The quantity of calcareous earth separated, by adding a fixed alkali, from a hundred measures of water, each of which contained 36 ounces, was 132 grains; and the quantity separated by the same means from an equal quantity of snow-water was 72 grains.

The *purity of water* may be known by the following marks or properties of pure water.

1. Pure water is lighter than water that is not pure; for not only the substances usually dissolved in water, fixable and atmospherical air excepted, are heavier than water, but also the specific gravity of a solution of any of these substances in water is greater than the intermediate specific gravity of the water and of that substance. We must nevertheless observe, that as fixable and atmospherical airs are frequently contained in water, they render it less heavy than it would otherwise be. Hence Bath, and other waters containing much fixable air, are lighter than distilled water, although the former contain saline, metallic, and earthy substances.

2. Pure water is more fluid than water that is not pure: hence it is said to occasion a louder sound when poured from one vessel into another.

3. It has no color, smell, or taste.

4. It wets more easily than the waters containing metallic and earthy salts, called *hard waters*, and feels softer when touched.

5. Soap, or a solution of soap in spirit of wine, mixes easily and perfectly with it.

6. It is not rendered turbid by adding to it a solution of gold in aqua regia, or a solution of silver, or of lead, or of mercury in nitrous acid, or a solution of sugar of lead in water.

Boerhaave, the author of this Dictionary, and other chemists, maintain, that pure water is unalterable; and others, as Borichius, Boyle, Wallerius, that it may be decomposed or resolved into other principles, especially into earth.

Boyle relates, that one ounce of water, distilled carefully in glass-vessels two hundred times, yielded six drams of a white, light, insipid earth, fixed in the fire, and indissoluble in water. Boerhaave attributed the earth obtained by distillation of water to dust floating in laboratories. Other chemists have made experiments to ascertain the truth of that of Mr. Boyle. Liedenfrost found, that when pure distilled water is dissipated or evaporated by throwing it into a red-hot iron spoon, he always obtained a quantity of earth. Wallerius obtained a scruple and a half of fine white earth by triturating during two hours a dram of distilled water.

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DCCXXV. WATERS (AROMATIC). Those are called aromatic waters that are impregnated by distillation with the spiritus rector, or odoriferous principle of aromatic matters. *See* WATERS (DISTILLED).

This earth, he says, is soluble in acids, is convertible into a hard mass by a red-heat, which mass is unsoluble by acids, and is vitrifiable into a white transparent glass by a more violent heat. He found also, that a large quantity of earth is deposited from boiling water with a strong, then with a gentle fire. *See the Swedish Memoirs for the year* 1760. Mr. Margraaf has made experiments with his accustomed accuracy, from which it appears, that, by distillation, and also by evaporation with the heat of the sun, of rain water, the purity of which had been previously ascertained by thirteen distillations, he obtained a white, light, shining earth. This earth could not be vitrified with the heat requisite for the fusion of ordinary glass; but by a more violent and longer continued fire it was melted into a yellow-greyish mass. He found, that about half of this earth was soluble in nitrous acid, and that the other half was not fusible by fire; but that, by addition of half its quantity of salt of tartar, it was convertible into a transparent glass. The part of the earth that was dissolved in nitrous acid was afterwards precipitated from that acid by vitriolic acid, with which it formed a selenites; and hence Mr. Margraaf infers, that it is a true calcareous earth. He does not determine the class of earths to which the unsoluble part of the earth thus obtained by distilling water ought to be referred. Mr. Margraaf observes, that earth is more copiously deposited from water boiling with a strong than with a gentle heat. The quantity of earth that he obtained, in one experiment, from 72 ounces of distilled water, by twelve distillations, was nine or ten grains.

Mr. Eller relates an account of a more extraordinary alteration produced upon water, by which other principles were formed. He enclosed some distilled water in a glass phial, which he then hermetically sealed, and exposed during some weeks in summer to the rays of the sun. At the end of this time he perceived that it was become turbid, and covered with a scum or pellicle. By distillation he obtained from this water a reddish oil, and some acid fumes. That so extraordinary an alteration can be produced upon pure water by the rays of the sun, cannot be admitted till the experiment has been carefully repeated with the same success.

To this article we shall subjoin three tables of different authors, shewing what quantity of each salt is soluble in a given quantity of water; and also an account of some experiments made by Mr. Eller, to shew how much of certain salts may be dissolved in given quantities of water saturated previously with other salts.

The following table shews the quantities of the saline substances that could be dissolved in an ounce of water, with the heat of 50° of Fahrenheit's scale, according to experiments made by Mr. Spielman. *Instit. Chemiæ*, *p.* 48.

	Grains
Terra foliata tartari	470
Salt of Sedlitz	384
Epsom salt	324
Salt of tartar	240
Vegetable salt	212
White vitriol	210
Sal gem	200
Salt of soda	200
Sal ammoniac	176
Common salt	170
Salt of Glauber	168
Salt of Lorraine	168
Salt of Sylvius	160
Salt of Seignette	137
Blue vitriol	124
Green vitriol	80
Purified nitre	60
Salt polychrest of Glaser	40
Vitriolated tartar	30
Sublimate mercury	30
Borax	20
Alum	14
Volatile salt of amber	5
Arsenic	5
Crude tartar	4
Cream of tartar	3

DCCXXVI. WATER (DISTILLED). Moſt natural waters contain ſome heterogeneous ſubſtances that render them impure; and as water exceedingly pure is required for many chemical operations, it muſt be therefore purified for theſe purpoſes by diſtillation. Water may be diſtilled in the following manner:

The following table is copied from Mr. Muſchenbroek. The eight firſt experiments were made by Boerhaave, and the reſt byMuſchenbroek, with a heat of 38°.

Sea-ſalt,	oz. 2.	were diſſolved in	oz. 6. and dr. 3.	of pure water.
Sal gem,	oz. 1.	——	oz. 3. and dr. 2.	——
Sal ammoniac,	oz. 1.	——	oz. 3. and dr. 2.	——
Nitre,	dr. 9.	——	oz. 6.	——
Borax,	dr. 4.	——	oz. 10.	——
Alum,	oz. 1.	——	oz. 14.	——
Epſom ſalt,	oz. 1.	——	oz. 1. and dr. 2.	——
Green vitriol,	dr. $1\frac{1}{2}$	——	oz. 3.	——
Arſenic,	oz. 1.	——	oz. 30.	——
Blue vitriol,	gr. 50.	——	gr. 850.	——
Salt of hartſhorn,	gr. 50.	——	gr. 765.	——
Sugar of lead,	gr. 50.	——	gr. 595.	——
Salt of tartar,	gr. 50.	——	gr. 85.	——
Glaſs-gall,	gr. 50.	——	oz. $7\frac{1}{2}$.	——
Cream of tartar,	gr. 50.	——	gr. 1000.	of boiling water.

[Fifty grains of cream of tartar may be diſſolved in 100 grains of lime-water. *Hiſt. de l'Acad. Royale.* 1732.]

Sugar of milk, dr. 7. were diſſolved in lb. 1. of water heated to the 167°.

According to Neuman's experiments, the quantity of ſalt ſoluble in an ounce of water are expreſſed in the following table. He does not mention the heat employed.

White powdered ſugar,		oz. 2.
Brown powdered ſugar,	—	oz. 2.
White or brown ſugar candy,		dr. 9.
Sal diureticus	— —	oz. 1.
Epſom ſalt,	——	oz. 1.
Sedlitz ſalt,	— ——	dr. 6.
Pure fixed alkali,	——	dr. 6.
White vitriol,	——	oz. $\frac{1}{2}$.
Martial vitriol,	— —	oz. $\frac{1}{2}$.
Sal gem,	—— ——	dr. 3. ſcr. 1.
Sea-ſalt,	— — —	dr. 3.
Salt of Glauber,	——	dr. 2.
Sal ammoniac,	——	dr. 2.
Vol. ſal ammoniac,	—	dr. 2.
Potaſh,	— — —	dr. 2.
Blue vitriol,	—— ——	dr. 2.
Pure nitre,	——	dr. 1. gr. 10.
Sal prunell,	— — —	dr. 1.
Soluble tartar,	——	dr. 1.
Alum,	—— ——	ſcr. $2\frac{1}{2}$.
Sal polychreſt,	—— —	ſcr. 2.
Arcanum duplicatum,	—	dr. $\frac{1}{2}$.
Vitriolated tartar,	——	dr. $\frac{1}{3}$.
Sugar of milk,	— —	ſcr. 1.
Sugar of lead	——	ſcr. 1.
Emetic tartar,	— —	ſcr. 1.
Borax,	— —— —	gr. 15.
Salt of ſorrel	——	gr. 10.
White tartar,	—— ——	gr. 5.
Cryſtals of tartar,	— —	gr. 5.

* Water, when ſaturated with one ſalt, is capable of diſſolving a conſiderable portion of another ſalt; and when ſaturated with this alſo, it may ſtill diſſolve a third, a fourth, or more ſalts. Thus, according to Neuman, four ounces of water that have been ſaturated with a dram and a few grains of alum, will ſtill diſſolve five drams of nitre, then half an ounce of green vitriol, ſix drams of common ſalt, three drams of ſoluble tartar, and five drams of ſugar. In the ſame manner alſo, four ounces of water ſaturated with half an ounce of nitre, will diſſolve half an ounce of white vitriol, ſix drams of common ſalt, ſix drams of ſal ammoniac, half an ounce of ſoluble tartar, and

The pureſt natural water that can be procured, as the water of rain or of ſnow, or of ſprings and rivers that flow over ſands, and are very limpid, is to be put into a well-tinned copper alembic, which muſt be very clean, or which is only employed for this purpoſe, and the diſtillation is to be promoted with a gentle fire.

The firſt portion of water that paſſes into the receiver ought to be thrown away, becauſe it waſhes the alembic and receiver, and becauſe if the water contained accidentally any volatile heterogeneous matters, theſe will riſe with the firſt portion of diſtilled water.

The diſtillation is to be diſcontinued, when two-thirds of water have nearly paſſed, becauſe what remains in the alembic, is loaded with a larger proportion of heterogeneous ſubſtances, ſome of which the water might raiſe along with it in diſtillation. *See* DISTILLATION.

Diſtilled water ought to be put into very clean bottles, and ſtopped with glaſs ſtopples.

Water is known to have been ſufficiently purified by diſtillation, when it does not change the color of the tinctures of violets, or of turnſol, and when its limpidity is not hurt by adding to it ſolutions of mercury or of ſilver in nitrous acid.

DCCXXVII. WATERS (DISTILLED). The *diſtilled waters of plants*, or of *other matters*, are prepared by diſtilling water from theſe ſubſtances, and are thus impregnated with ſuch principles as may be raiſed by diſtillation, with the heat of boiling water.

If the plants thus expoſed to diſtillation with water, manifeſtly contain volatile principles, as all thoſe do which have a diſtinguiſhing ſmell, we cannot doubt that

and after all theſe, an entire ounce of ſugar.

Mr. Eller has publiſhed an account of the following experiments concerning the ſolution of different ſalts in the ſame water. *See Mem. of the Acad. of Berlin for the year* 1750.

In each experiment he employed *eight ounces of diſtilled water*. He found that this quantity of water, when ſaturated

With four ounces of nitre, diſſolved one ounce, five drams of fixed alkali, and half an ounce of common ſalt:

With three ounces, one dram, and one ſcruple of common ſalt, diſſolved three drams of nitre, and five drams of fixed alkali:

With three ounces and a half of foſſil ſalt, diſſolved half an ounce of nitre:

With half an ounce of cream of tartar, diſſolved half an ounce of Sedlitz ſalt, and half an ounce of fixed alkali:

With an ounce and a half of vitriolated tartar, diſſolved half an ounce of fixed alkali:

With three ounces and a half of Glauber's ſalt, diſſolved two drams of nitre, and as much ſugar.

With four ounces of ſoluble tartar, diſſolved half an ounce of pure nitre.

With four ounces of Epſom ſalt, diſſolved half an ounce of fine ſugar.

With two ounces and a half of ſal ammoniac, diſſolved five drams of foſſil ſalt.

With an ounce and a half of volatile ſalt of hartſhorn, diſſolved an ounce of nitre and half an ounce of ſugar.

With four drams and two ſcruples of borax, diſſolved half an ounce of fixed alkali.

With two ounces and a half of alum, diſſolved ſix drams of common ſalt, and one dram of Epſom ſalt:

With nine ounces and a half of green vitriol, diſſolved an ounce and a half of Sedlitz ſalt, two drams of nitre, and three ounces of refined ſugar:

With nine ounces of blue vitriol, diſſolved an ounce of nitre, three drams of common ſalt, and an ounce of ſugar:

With four ounces and a half of white vitriol, diſſolved one ounce of refined ſugar.

that their diſtilled water muſt be impregnated with their odoriferous principle, or ſpiritus rector. Theſe waters are called *aromatic waters. See* SPIRITUS RECTOR.

The water that is uſed in the diſtillation of all eſſential oils is found much impregnated with the odoriferous principle of the aromatic plants employed; and conſequently it is a good diſtilled water of theſe plants.

An opinion ſeems to have formerly prevailed, that even the plants called *inodorous*, might impregnate water with ſome of their principles by diſtillation; for ſuch diſtilled waters are preſcribed in many diſpenſatories. But lately, theſe diſtilled waters have been neglected, and are even conſidered only as common water. This latter kind of diſtilled waters is ſenſibly leſs impregnated with principles than the former. But are we certain that they contain nothing of the principles of the plant? Are thoſe plants whoſe ſmell is not very perceptible, entirely deſtitute of all odoriferous principle? Could not a perſon whoſe ſenſe of ſmell was very acute and much exerciſed, diſtinguiſh plantain and other herbs commonly called inodorous from each other by ſmell, eſpecially if they were previouſly cut and bruiſed?

We may alſo obſerve, that the manner commonly employed for diſtilling ſuch waters is not well adapted to procure all the peculiar ſmell and qualities of the plants employed. The plants are generally put into an alembic, and overwhelmed with a large quantity of common water. The diſtillation is then promoted; the water is made to boil quickly; and the veſſels are ſeldom even luted. What can be expected from this bad management, but that the ſpiritus rector of theſe plants that is in very ſmall quantity, and perhaps exceedingly volatile and fugacious, ſhould be entirely diſſipated; or if any of it remains in the water, that it ſhould be diſguiſed and covered by the empyreumatic ſmell that all theſe waters have when newly diſtilled, or by the ſmell which they acquire by time, ſo that they cannot be diſtinguiſhed from each other?

But if we follow exactly the excellent method directed in the Paris Diſpenſatory; or if we improve upon this by putting the herbs recent, cut, and bruiſed, into an alembic placed in a water-bath, without adding water to them, and by diſtilling to dryneſs, with a very gentle heat and well luted veſſels; and if we then find that the ſmall quantity of water thus diſtilled from plants called inodorous has no ſmell nor taſte, and gives all the chemical proofs of pure water, we may then juſtly conſider theſe waters as deſtitute of any of the principles and virtues of the plants employed.

Waters called ſimply *diſtilled waters*, are underſtood to be thoſe that are prepared with common water. But as ſpirit of wine is alſo frequently impregnated with the odoriferous principle of plants and other ſubſtances by diſtillation, and as theſe alſo have been called *waters*, they ought to be diſtinguiſhed by the name, *aromatic ſpirituous waters*. Such are the *ſpirituous water of Lavender*, the *ſpirituous water of thyme*, &c. Theſe ſpirituous waters are alſo ſometimes called *ſpirits*, as *ſpirit of thyme*, *ſpirit of citrons*, &c.

Aromatic ſpirituous waters are impregnated with the ſmell of one ſubſtance only, or of ſeveral ſubſtances. The former are called *ſimple*, and the latter, *compound*.

Many of theſe waters are prepared for the uſes of medicine, of the toilette, and of the table. The preparation of theſe waters requires only the uſual attentions to be given to all diſtillations. Whatever relates to this ſubject may be found in *Mr. Beaumé's Elements of Pharmacy*. We ſhall there ſee that the ſtrength

ſtrength and agreeable flavor of theſe waters chiefly depend on the ſtrength of the ſpirit of wine employed, and eſpecially on its purity from any oil of wine, which gives the diſagreeable ſmell and taſte of common aqua vitæ. *See* SPIRIT (ARDENT).

DCCXXVIII. WATERS (HARD *or* CRUDE). Theſe names are applied to all waters that contain any ſenſible quantity of earth or ſelenites. *See* WATERS (MINERAL). (*t*)

DCCXXIX. WATER (LIME). Lime-water is ordinary water in which quicklime has been ſlaked.

Water in which quicklime has been ſlaked, or with which ſlaked quicklime is waſhed, diſſolves the part of the quicklime that is moſt attenuated, and neareſt to a ſaline ſtate : this ſubſtance, which may be conſidered as ſaline and earthy, communicates to water an alkaline, and ſomewhat acrid taſte. The effects of lime-water in chemical mixtures are ſimilar to thoſe produced by quick-lime. *See* QUICK-LIME.

Although lime-water contains no volatile principle, it ought nevertheleſs to be preſerved in full and well cloſed bottles : otherwiſe the ſaline earthy matter diſſolved in it, to which it owes all its peculiar properties, would be ſeparated from it, in proportion as the water ſhould be evaporated, and would appear on the ſurface in form of a cruſt, called *cream of lime*. The quantity of calcareous matter that is thus ſeparated from lime-water, is even greater than it ought to be, if it was exactly proportionate to the evaporation of the water. The cauſe of which probably is, that the firſt portions of this matter which cryſtallize, draw along with them another part that would otherwiſe have remained diſſolved in the water. Hence lime-water, by long expoſure to air, loſes much of its ſtrength, and at laſt becomes almoſt inſipid. *See a note ſubjoined to the article* QUICK-LIME.

(*t*) *Hard waters* are thoſe in which ſoap does not diſſolve uniformly, but is curdled. The diſſolving power of hard water is leſs than that of *ſoft* ; and hence its unfitneſs for bleaching, dyeing, boiling leguminous vegetables, and for many other purpoſes of economy and arts. One cauſe of the hardneſs of water is, that it contains ſome ſalt that may be decompoſed by ſoap, the alkali of which uniting with the acid of the ſalt, the oil of the ſoap ſeparates, and the ſoap is ſaid to be curdled. Hardneſs of water proceeding from this cauſe may be diſcovered and cured by adding ſome drops of a ſolution of fixed alkali. The ſalts capable of rendering water hard, are not only ſelenites, which is a very frequent cauſe of the hardneſs of water, but any other earthy or metallic ſalt that may be contained in the water, as all theſe are capable of being decompoſed by fixed alkali. Such are the marine ſalt with baſis of magneſia, or of calcareous earth, vitriolic ſalt with baſis of magneſia called Epſom ſalt, green vitriol, and a nitrous ſalt with earthy baſis, to which Dr. Home attributes the hardneſs of ſeveral waters examined by him. The hardneſs of water has been by ſome perſons attributed to common ſalt. But Dr. Home in his *Eſſay on Bleaching* has ſhewn, that neither pure common ſalt, nor any other ſalt with baſis of fixed alkali, give any hardneſs to water, but that this quality may be given to water by the common ſalt which is generally ſold, becauſe this contains ſome part of the earthy ſalts of ſea-water, or of the water of ſalt-ſprings.

Fixable air which waters frequently contain, is another cauſe of the hardneſs of water. This air unites with the alkali of ſoap, renders it mild, and thus weakens its union with the oil. *See* AIR FIXABLE, *and* ALKALI (FIXED). This fixable air, by expoſure of the water during ſome time in open veſſels, exhales ; by which means, water is rendered ſoft, and any calcareous earth or

DCCXXX. WATER (MERCURIAL). This name is given to a solution of mercury in nitrous acid, diluted with a greater or less quantity of common water.

This liquor produces very good effects, as an escharotic, and even as a caustic in some diseases of the skin that are external, local, and especially venereal. Some persons use this mercurial water internally; but as it must be a dangerous remedy, it ought not to be employed.

DCCXXXI. WATERS (MINERAL). All waters naturally impregnated with any heterogeneous matter which they have dissolved within the earth may be called *mineral waters*, in the most general and extensive meaning of that name; in which are therefore comprehended almost all those that flow within, or upon the surface of the earth: for almost all these contain some earth or selenites. But waters containing only earth or selenites are not generally called *mineral*, but *hard* or *crude waters*.

Hard waters, when tried by the chemical proofs hereafter to be mentioned for discovering the nature of mineral waters, shew no marks of an acid or of an alkali, nor of any volatile, sulphureous, or metallic matters. Waters which contain a disengaged calcareous earth, change the color of syrup of violets to a green; and those that contain selenites, being mixed with a solution of mercury in nitrous acid, form a turbith mineral; and when a fixed alkali is added, they are rendered turbid, and a white sediment is precipitated. These waters also do not dissolve soap well. From these we may know, that any water which produces these effects is a hard, earthy, or selenitic water.

Although the waters of the sea, and saline springs, be not generally enumerated amongst mineral waters, they might nevertheless be justly considered as such. For besides earthy and selenitic matters, they also contain a large quantity of mineral salts. We shall therefore consider them as such in this article.

Mineral waters, properly so called, are those in which spirituous, sulphureous, saline or metallic substances are discovered by chemical trials. As many of these waters are employed successfully in Medicine, they are also called *medicinal waters*.

or iron which may be dissolved in the water merely by means of this air, as Mr. Cavendish and Mr. Lane have shewn [*Philos. Trans.* 1767 *and* 1769.] are precipitated.

By boiling, the hardness of water proceeding from fixable air may be cured, but that from earthy or metallic salts cannot.

Spring-waters are frequently hard. River water is generally soft. The small quantity of earthy salts contained in rain and snow waters, according to Mr. Margraaf's analysis, does not sensibly render them hard.

As rivers are formed by the junction of many springs, the greater hardness of the water of the latter seems to be not easily explicable. Does this difference betwixt these two waters proceed from fixable air being contained more copiously in springs, than in rivers, by the motion and free exposure of which it is mostly exhaled? or from a larger quantity of atmospherical air being contained in the water of rivers by means of their motion and free exposure, than in the water of springs; as a mixture of atmospherical air with water is known to encrease the dissolving power of this liquid? or from both these causes united?

Mineral

Mineral waters receive their peculiar principles by paſſing through earths containing ſalts, or pyritous ſubſtances that are in a ſtate of decompoſition. *See* PYRITES.

Some of theſe waters are valuable from the quantity of uſeful ſalts which they contain, particularly of common ſalt, great quantities of which are obtained from theſe waters; and others are chiefly valued for their medicinal qualities.

The former kind of mineral waters is an object of manufacture, and from them is chiefly extracted that ſalt only which is moſt valuable in commerce. *See* WATER *of the* SEA; and WATER *of* SALINE SPRINGS.

But the nature and proportion of all the principles of which medicinal waters conſiſt, ought to be carefully examined. Many of theſe waters have been accurately analyſed by able chemiſts and phyſicians.

But notwithſtanding theſe attempts, we are far from having all the certainty and knowledge that might be deſired on this important ſubject; for this kind of analyſis is perhaps the moſt difficult of any in chemiſtry.

Almoſt all mineral waters contain ſeveral different ſubſtances, which being united with water may form with each other numberleſs compounds. Frequently ſome of the principles of mineral waters are in ſo ſmall quantity, that they can ſcarcely be perceived; although they may have ſome influence on the virtues of the water, and alſo on the other principles contained in the water.

The chemical operations uſed in the analyſis of mineral waters, may ſometimes occaſion eſſential changes in the ſubſtances that are to be diſcovered. And alſo, theſe waters are capable of ſuffering very conſiderable changes by motion, by reſt, and by expoſure to air.

Probably alſo the variations of the atmoſphere, ſubterranean changes, ſome ſecret junction of a new ſpring of mineral or of pure water; laſtly, the exhauſtion of the minerals whence waters receive their peculiar principles, are cauſes which may occaſionally change the quality of mineral waters.

We need not therefore wonder that the reſults of analyſes of the ſame mineral waters made by different chemiſts, whoſe ſkill and accuracy are not queſtioned, ſhould be very different.

The conſequences of what we have ſaid on this ſubject are, that the examination of mineral waters is a very difficult taſk; that it ought not to be attempted but by profound and experienced chemiſts; that it requires frequent repetitions, and at different times; and laſtly, that no fixed general rules can be given concerning theſe analyſes.

As this matter cannot be thoroughly explained without entering into details connected with all the parts of chemiſtry, we ſhall here mention only the principal reſults, and the moſt eſſential rules, that have been indicated by the attempts hitherto made on this ſubject.

We may admit the diviſion or arrangement of mineral waters into certain claſſes, propoſed by ſome of the beſt chemiſts and naturaliſts.

Some of theſe waters are called *cold*, becauſe they are not naturally hotter than the atmoſphere. Some of them are even colder, eſpecially in ſummer.

Thoſe are called *hot mineral waters*, which in all ſeaſons are hotter than the air. Theſe are of various degrees of heat, and ſome of them are almoſt as hot as

boiling water. In ſome mineral waters certain volatile, ſpirituous and elaſtic principles may be perceived, by a very ſenſible piquant taſte; this principle is called the *gas* or the *ſpirit of waters.*

The waters which contain this principle are generally lighter than pure water. They ſparkle and emit bubbles, at their ſpring, but eſpecially when they are ſhook, and poured from one veſſel into another. They ſometimes break the bottles containing them, when theſe are well corked, as fermenting wines ſometimes do. When mixed with ordinary wine, they give to it the piquancy and ſparkling quality of Champaigne wine.

This volatile principle and all the properties of the water dependant upon it are loſt merely by expoſure to air. The waters containing this principle are diſtinguiſhed by the name of *ſpirituous mineral waters.*

Other diviſions of mineral waters may be made, relatively to ſome of their predominant principles. Hence ſome waters are called *acidulous*, *alkaline*, *martial*, *neutral*, &c.

When a mineral water is to be examined, we may obſerve the following rules:

Experiments ought to be made near the ſpring, if poſſible.

The ſituation of the ſpring, the nature of the ſoil, and the neighbouring riſing grounds ought to be examined.

Its ſenſible qualities, as its ſmell, taſte, color, are to be obſerved.

Its ſpecific gravity and heat are to be aſcertained by the hydroſtatical balance and the thermometer.

From the properties above-mentioned of ſpirituous mineral waters, we may diſcover whether it be one of this claſs. For greater certainty we may make the following trial. Let the neck of a wet bladder be tied to the neck of a bottle containing ſome of this water. By ſhaking the water, any *gas* that it may contain will be diſengaged, and will ſwell the bladder. If the neck of the bladder be then tyed with a ſtring above the bottle, and be cut below this ſtring, ſo as to ſeparate the bladder from the bottle, the quantity and nature of the contained *gas* may be further examined.

Laſtly, we muſt obſerve the changes that are ſpontaneouſly produced upon the water in cloſe and in open veſſels, and with different degrees of heat. If by theſe means any matter be cryſtallized or depoſited, it muſt be ſet apart for further examination.

Theſe preliminary experiments and obſervations will almoſt certainly indicate, more or leſs ſenſibly, ſomething concerning the nature of the water, and will point out the method to be followed in our further inquiry.

We muſt then proceed to the decompoſition of the water either without addition and merely by evaporation and diſtillation, or with the addition of other ſubſtances, by means of which the matters contained in the water may be precipitated, and diſcovered. It is not material which of theſe two methods be firſt practiſed, but it is quite neceſſary that the one ſhould ſucceed the other. If we begin by evaporating and diſtilling, theſe operations muſt be ſometimes interrupted, that the ſeveral principles which riſe at different times of the diſtillation may be obtained and examined ſeparately, and alſo to allow the ſeveral ſalts that may be contained, to cryſtallize by the evaporation and by cold. *See* EVAPORATION, DISTILLATION, *and* CRYSTALLIZATION.

The ſubſtances generally found in mineral waters, are almoſt always combinations of vitriolic acid, and thoſe of marine acid, together with the ſeveral matters that theſe acids are capable of diſſolving.

The following combinations of vitriolic acid are found in mineral waters.

1. *Volatile ſulphureous acid.* This is ſeldom found, both becauſe it eaſily loſes its phlogiſton, and becauſe it muſt almoſt always meet with ſome ſubſtance that it is capable of diſſolving.

2. *Sulphur.* This is found ſometimes ſingly, but generally in form of a liver of ſulphur. In theſe waters, ſulphur is formed into a hepar by means of calcareous earth, or of mineral alkali.

3. *Vitriolic ſalts with earthy baſes.* Theſe ſalts are almoſt always *ſelenitic*, that is, their acid is combined with a calcareous earth. Sometimes, but not ſo frequently, they are *aluminous*, when their acid happens to be united with an argillaceous earth.

4. *Vitriols. Martial vitriol* is frequently contained in mineral waters; *vitriol of copper* is ſometimes but ſeldom, and *vitriol of zinc* is ſtill more rarely found in theſe waters. The vitriols of other metallic ſubſtances are ſcarcely ever, but in very ſingular caſes, found in water.

5. Laſtly, *vitriolic ſalts with baſis of fixed alkali.* This is always *Glauber's ſalt.* Neither *vitriolated tartar* nor *vitriolic ammoniacal ſalt* are ever found, unleſs by ſome ſingular accident, in mineral waters.

The combinations of marine acid that are contained in mineral waters are *common ſalt*, and *marine ſalt with earthy baſis.* For no combinations of this acid with phlogiſton are known, and it is very ſeldom found united with any metallic ſubſtance.

Compounds formed of the nitrous acid are, in a manner, ſubſtances extraneous to the mineral kingdom, ſince this acid is never produced but upon the ſurface of the earth, and from vegetable and animal matters. *See* ACID (NITROUS) *and* NITRE. This acid cannot therefore be found in waters but very accidentally.

Theſe are the principal ſubſtances that form almoſt all theſe waters. We ſhall now ſhew the proofs by means of which they may be diſcovered in water, without decompoſing the water by evaporation or by diſtillation.

If any portion of diſengaged acid or alkali be contained in water, it may be known by the taſte, by changing the color of violets or of turnſol, and by adding the preciſe quantity of acid or of alkali that is neceſſary for the ſaturation of the contained diſengaged ſaline matter.

Volatile ſulphureous acid, ſulphur, and liver of ſulphur, may be diſcovered in waters by their ſingular ſmell, by the black color which theſe ſubſtances give to white metals or to their precipitates, but eſpecially to ſilver.

Vitriolic ſalts with earthy baſis may be diſcovered in water by two proofs: 1. By adding ſome fixed alkali, which decompoſes all theſe ſalts, and precipitates their earthy baſis; and, 2. By adding a ſolution of mercury in nitrous acid, which alſo decompoſes theſe ſalts, and forms a *turbith mineral* with their acid.

Martial vitriol or iron combined with any acid, ſhews itſelf in waters by blackening an infuſion of galls, or by forming a Pruſſian blue with the phlogiſticated alkaline lixivium.

The vitriol of copper, or copper diſſolved by any acid, may be diſcovered by adding ſome of the volatile ſpirit of ſal ammoniac, which produces a fine blue color, or by the addition of clean iron, upon the ſurface of which the copper is precipitated in its natural or metallic ſtate.

Glauber's ſalt is diſcovered by adding a ſolution of mercury in nitrous acid, and forming with it a turbith mineral; or by cryſtallization.

Common ſalt contained in waters forms with a ſolution of ſilver in nitrous acid a white precipitate, or luna cornea. It may alſo be known by its cryſtallization. Marine ſalt with earthy baſis produces the ſame effect upon ſolution of ſilver. It alſo forms a precipitate when fixed alkali is added. The acrimony, bitterneſs, and deliqueſcency of this ſalt ſerve to diſtinguiſh it.

The proofs related for the examination of mineral waters are only thoſe which are moſt eſſential. Many others may be made to confirm the former proofs: but the details of theſe are too extenſive to be inſerted here. We ſhall add only two of theſe, becauſe they are very general, and may be very uſeful.

The firſt is the production of artificial ſulphur, or of the volatile ſulphureous acid; by which means the vitriolic acid may be diſcovered in any combination whatever. For this purpoſe the matter to be examined muſt be mixed with any inflammable ſubſtance, and expoſed to a red heat. If this matter contained but a particle of vitriolic acid, it would be rendered ſenſible by the ſulphur, or by the volatile ſulphureous acid thence produced. *See* SULPHUR.

The ſecond general proof for mineral waters which we ſhall mention here ſerves to diſcover any metallic ſubſtance whatever, diſſolved in water by any acid. This proof conſiſts in adding ſome of the liquor ſaturated by the coloring matter of Pruſſian blue, diſcovered and deſcribed by Mr. Macquer in his Memoir upon Pruſſian Blue. This liquor produces no effects upon any neutral ſalts with earthy or alkaline baſes, but decompoſes all metallic ſalts: ſo that if no precipitate be formed upon adding ſome of this liquor, we may be certain that the water does not contain any metallic ſalt; and on the contrary, if a precipitate is formed, we may certainly infer that the water does contain ſome metallic ſalt.

Two kinds only of *gas*, or the ſpirituous volatile part of ſome waters, are hitherto known; of which one is the volatile ſulphureous acid, and the other is pure air, as Mr. Venel has ſhewn in the waters of Sel or Selters. Air united ſuperabundantly with ſpirituous waters is the chief cauſe of their lightneſs, piquancy, and ſparkling.

When the nature and quantities of the principles contained in a mineral water are aſcertained by ſuitable experiments, it is very proper to attempt to imitate artificially this water, by adding to pure water the ſame proportions of the ſame ſubſtances, as Mr. Venel has done in examining ſeveral waters, eſpecially that of Selters.

We may eaſily perceive the neceſſity of uſing no veſſels in theſe experiments, but ſuch as are perfectly clean and rinſed with diſtilled water; of weighing the products of the experiments very exactly; of making the experiments upon as large quantities of water as is poſſible, eſpecially the evaporations, cryſtallizations, and diſtillations; and of repeating all experiments ſeveral times. We may further obſerve, that the mixtures from which any precipitates might be expected,

expected, ought to be kept two or three days, becauſe many of theſe precipitates require that time or more to appear, or to be entirely depoſited.

We ſhall now endeavor to explain how mineral waters become impregnated with their principles.

The *ſelenitic* parts of water are received by this fluid while it flows through gypſeous earths and ſtones, theſe being compoſed of ſelenites, which is ſoluble in water.

The mines of ſal gem which are in many places, and particularly where ſalt-ſprings are, furniſh the waters which flow through them, and perhaps the ſea itſelf, with the *common ſalt* that they contain.

When a water once contains common ſalt, it may become impregnated with *Glauber's ſalt* by paſſing through clay; the vitriolic acid that is always contained in argillaceous earths, decompoſing a part of the common ſalt of the water, with the baſis of which it forms the Glauber's ſalt; while the marine acid now diſengaged will unite with the firſt calcareous particles that it meets, and form a *marine ſalt with earthy baſis*, which is accordingly always found in ſea-water, and in ſalt-ſprings.

When water impregnated, or not, with ſaline principles flows through parts of the earth containing pyrites in a ſtate of decompoſition, it becomes impregnated with *ſulphur*, with *martial vitriol*, with *vitriol of copper*, with *alum*, and with *other ſalts*; and frequently with ſeveral of theſe ſubſtances at the ſame time, according to the nature of the pyrites. *See* PYRITES.

The *heat of hot mineral waters* can be only acquired by waſhing large maſſes of pyrites and other ſimilar minerals in a ſtate of ſpontaneous decompoſition, during which they always acquire conſiderable heat.

Laſtly, the aerial *gas* of ſome mineral waters may have been diſcharged from ſome of the principles with which the water is impregnated, which were in the act of combination with each other at the time they were diſſolved by the water, or which were combined after this ſolution. For we know that in almoſt all ſolutions much air is extricated; and this air being well divided and diffuſed among the particles of water, adheres to them, and in ſome meaſure combines with them ſuperabundantly. Mr. Venel has made upon this ſubject a fine experiment, that proves the truth of the above-mentioned theory, which was firſt given by him. He added to common water as much marine acid and mineral alkali as were ſufficient to form as much common ſalt as is contained in the mineral water of Selters. He corked very well the bottle containing this impregnated water. The combination proceeded ſlowly and without effervescence, becauſe the ſaline matters were much diluted; and when the combination was completed, the artificial water was become ſpirituous and aerial, like the natural water that he imitated. *See the particular articles of all the ſubſtances mentioned that relate to mineral waters; from a knowledge of the properties of which ſubſtances many explanations on this ſubject may be deduced, too long to be here inſerted.* (*u*)

(*u*) The *gas* which gives the ſparkling and inebriating qualities to many mineral waters, ſeems not to differ from the vapor extricated from effervescing and fermenting ſubſtances, called *fixable air*. *See* AIR (FIXABLE). The Honourable Mr. Cavendiſh has added to his former important diſcoveries concerning fixable air, one that throws much light on the nature

DCCXXXII. WATERS (MOTHER). This name is given to the liquor that remains after as much of the saline substances contained in a water has been separated as can be by the usual methods, evaporation and cooling, and from which therefore no more crystals can be obtained, without much difficulty, though it still remains impregnated with salts. These mother-waters are very different, according to the kinds of salts with which the waters were originally impregnated. They are generally very heavy, acrid, and red.

The nature of mother-waters was a long time very imperfectly understood. They were considered as liquors loaded with greasy and viscid matters, by means of which the salts contained were prevented from crystallizing.

A portion of crystallizable salt, similar to those already extracted, does indeed remain in the mother-waters; and perhaps also the crystallization of these may be impeded by the viscid matters that are sometimes contained in these waters: but generally the greatest part of the matter contained in mother-waters is

nature of many mineral waters. This discovery is, that by means of fixable air, and without the intervention of any acid, calcareous earth is dissolved in some mineral waters. He found that the quantity of this air that was contained in Rathbone-place-water, relatively to the quantity of calcareous earth contained in that water, was about twice as much as is usually combined with an equal quantity of calcareous earth; and that the earth might be precipitated from this water by driving off the fixable air by heat, or by absorbing it by the addition of lime-water. Does not this solution of calcareous earth by fixable air confirm a conjecture concerning the analogy of this vapor with acids? It seems very extraordinary that calcareous earth saturated with its usual quantity of air should be unsoluble in water, but that it may be rendered soluble, either by depriving it entirely of this air, as it is in lime-water, or by uniting it with a superabundant quantity of air, as it is in the water of Rathbone-place. *See Phil. Transf. for the Year* 1767.

Mr. Lane has discovered another instance of the dissolving power of fixable air upon iron, and has, by some ingenious experiments, shewn the probability that this metal is dissolved in many mineral waters by means only of that air. He found that pure distilled water, having been impregnated with the fixable air arising from effervescing or fermenting substances, was rendered capable of dissolving a sensible portion of iron; and that this artificial chalybeate water, by exposure to air, lost entirely its property of tinging an infusion of galls. As several chalybeate mineral waters do also, by exposure to air, entirely lose their property of tinging an infusion of galls; and as waters containing iron dissolved by means of vitriolic acid, though a considerable sediment is also deposited from them, do never entirely lose this property; he infers, that the former kind of waters receive their chalybeate impregnation by means, not of an acid, but of this air. He further shews, from experiments, that iron cannot be so entirely precipitated from its solution in any of the mineral acids by means of mild alkalis, or mild calcareous earth, that this solution shall lose its power of tinging an infusion of galls; but that the iron may be so perfectly precipitated from the above-mentioned solutions by means of caustic alkali, or of lime-water; and hence he infers, that in the former case the portion of iron that is not precipitated is kept suspended or dissolved by means of the fixable air extricated by the acid of the solution from the mild alkali or earth. *See Phil. Transf. for the Year* 1769.

In the above article concerning mineral waters, the Author of the Dictionary considers nitre or nitrous acid as substances not to be found in native waters, but by some accidental occurrence. Nevertheless, from the experiments of Mr. Margraaf on the waters of the wells at Berlin, of Dr. Heberden on those of London, and of Dr. Home on those of some wells in Scotland, we have reason to believe, that true nitre and a nitrous salt with earthy basis are frequently contained in waters of springs, especially in towns.

composed

composed of salts that are deliquescent and different from those already obtained by crystallization. We are certain, at least, that the mother-waters of sea-salt and of nitre are formed almost entirely of these salts, which have a certain kind of adhesion to the crystallizable salts, and which therefore prevent the crystallization of the last portions of these. The mother-water of common salt contains a considerable quantity of marine salt with earthy basis, and the mother-water of nitre contains not only marine salt with earthy basis, but also a considerable quantity of nitre with earthy basis: hence, if a fixed alkali be added to these waters, a white earthy precipitate is formed so copiously, that the whole becomes a kind of paste. By diluting this paste with much water, the earth may be obtained by filtration. The earth when edulcorated is very white, and of a calcareous nature. It is called *magnesia*. (x)

If vitriolic acid be added to these mother-waters, a very copious white precipitate is likewise formed. This precipitate also proceeds from the union of this acid with the calcareous earth of the earthy salts, by which a selenites is formed. This selenites, not being soluble in so small a quantity of water as that of the mother-water employed, is mostly precipitated in form of an earthy sediment consisting of very minute crystals. *See* SALTS *with* EARTHY BASIS, *and* MAGNESIA.

DCCXXXIII. WATER *of* RABEL. The water of Rabel is vitriolic acid dulcified by mixture with rectified spirit of wine. Rabel, the inventor of this liquor, which is used in medicine, employed an expensive apparatus in the preparation of it. He obtained the vitriolic acid from pyrites: but since his time, the process has been much simplified, as it ought to be. One part of oil of vitriol is mixed with three parts of rectified spirit of wine, and the mixture is digested in a well-closed vessel. The vitriolic acid acts upon all the principles of the spirit of wine, and combines with them in a certain degree during this digestion: hence the acidity of the liquor is considerably diminished, but not perfectly destroyed. This water of Rabel may be considered as a dulcified vitriolic acid. *See* ETHER.

Water of Rabel is employed in medicine as an astringent, from the property which the vitriolic acid has of constringing the fibres and vessels. It requires to be diluted in some proper vehicle, as in potions or juleps.

DCCXXXIV. WATER (SEA). Sea-water, and the waters of many salt-lakes, wells, and springs, containing various kinds of salts, is in much greater quantity than fresh-water.

We may say in general, that all natural salt-waters contain four kinds of salts, namely, common salt, Glauber's salt, selenites, and marine salt with earthy basis. These salts are in different quantities and proportions, according to the nature of the waters; but the quantity of the common salt is always greater than that of any other.

(x) Magnesia is an earth not convertible into quicklime, therefore different from calcareous earth, with which the Author of the Dictionary confounds it, and is possessed of peculiar properties. *See the article* MAGNESIA, *and the* NOTE *subjoined.* The mother-waters of common salt and of nitre do also contain some marine and nitrous salts with basis of calcareous earth, as appears from the formation of selenites upon adding vitriolic acid, as is mentioned in the following paragraph of the text.

All

All theſe waters have a ſaline, and more or leſs of an acrid, bitter taſte. The acrimony and bitterneſs of theſe waters are generally attributed to bituminous matters ſuppoſed to be contained in them: but I can affirm, that I have made many experiments on large quantities of theſe ſeveral waters, and that I could never find any ſenſible quantity of bitumen. The bitterneſs, therefore, of theſe waters ought to be attributed to the Glauber's ſalt, which is bitter, and eſpecially to the marine ſalt with earthy baſis, which is very bitter and acrid.

Sea-water is not every-where impregnated with an equal quantity of ſalt. Generally, it has been obſerved to contain more ſalt in hot than in cold climates. The quantity of common ſalt contained in ſea-water is to the quantity of that water as three or four to a hundred. The water is conſequently far from being ſaturated with that ſalt; for water is capable of diſſolving nearly a fourth part of its weight of common ſalt.

Common ſalt is obtained from ſea-water by evaporation alone, and not by alternate evaporation and cooling; becauſe this ſalt is equally ſoluble in cold as in hot water. *See* CRYSTALLIZATION, *and* SALT (COMMON).

In the ſouthern provinces of France, and in all equally hot or hotter climates, ſea-water is evaporated in open air, and merely by the heat of the ſun in ſummer, by which means the common ſalt is obtained. For this purpoſe, large baſons are made in the ground near the ſea, called ſalt-marſhes. They are ſo diſpoſed that the ſea-water may flow into them at certain tides, and be retained there. Theſe marſhes are divided into many compartments, communicating with each other, into which any required quantity of water may be admitted. The water in theſe is of a ſmall depth, that the evaporation may advance more quickly. When the water is ſufficiently evaporated, and the ſalt is cryſtallized, more water is admitted, till a ſufficient quantity of ſalt is obtained, which is then gathered in heaps and drained

In the northern provinces of France common ſalt is obtained from ſea-water in the following manner:

A quantity of ſand moiſtened with ſea-water is expoſed to the ſun and dried, which is quickly done, becauſe the ſea-water is almoſt entirely near the ſurface of the ſand. The ſand, which then becomes covered with a conſiderable quantity of ſalt, is to be waſhed with as much water as is neceſſary for the ſolution of the ſalt adhering to it; and this water is afterwards evaporated over the fire in leaden cauldrons, till the ſalt is cryſtallized.

Wallerius ſays, that in northern countries the ſalt in ſea-water is concentrated by expoſure to intenſe cold, by which great part of the water is frozen, and the unfrozen part, which contains almoſt all the ſalt, is afterwards evaporated by fire, till the ſalt is cryſtallized.

After the common ſalt has been thus obtained by theſe operations from ſea-water, a liquor, called *mother-water*, remains that contains much ſalt, which cannot be cryſtallized. If this water be further evaporated, and then expoſed to cold, a certain quantity of Glauber's ſalt will be formed, which is very impure and badly cryſtallized, and is generally called *Epſom ſalt*. *See* SALT (EPSOM). *(y)*

(*y*) The ſalt called *Epſom ſalt*, or ſal catharticus amarus, large quantities of which are obtained from the mother-water remaining after the evaporation of ſea-water, and which

Laſtly, the remaining part of the mother-water contains ſcarcely any thing but marine ſalt with earthy baſis, the earthy part of which may be precipitated by an alkaline lixivium. This earth is called the *Magneſia of common ſalt. See* WATER (MOTHER), *and* MAGNESIA.

DCCXXXV. WATER *of* SALT-SPRINGS. The water of almoſt all ſalt ſprings, at leaſt of thoſe from which common ſalt is obtained, contains exactly the ſame principles as ſea-water, but generally in a larger quantity. Some of theſe ſprings contain ſixteen pounds of ſalt in a hundred pounds of water. Such, for inſtance, is that of Dieuſe in Lorraine, one of the beſt ſalt-works known. Other ſprings contain a much ſmaller proportion of ſalt; ſuch is that of Montmorot in Franche-compté.

Salt is obtained from theſe ſalt-ſprings generally by evaporation over the fire; at leaſt, it is ſo in Lorraine, and in Franche-compté: but that the expence of fuel may be leſſened, the water, when weakly impregnated, is previouſly concentrated by frequently pouring it upon bundles of twigs or faggots under buildings that are covered, but open at all the ſides, called *graduating houſes.* The water raiſed by pumps to the top of theſe buildings falls upon the faggots, by which it is divided into a ſhower, its ſurface is thereby encreaſed, and the evaporation is promoted by the free current of air that paſſes through the open ſides of the building. When, by this means, the water is ſo concentrated that a hundred pounds of it contain about thirteen or fourteen pounds of ſalt, it is then evaporated over the fire in the uſual manner.

As theſe waters are much more impregnated with ſaline principles than ſea-water, and as their evaporation is more quickly finiſhed, we ſhall confirm what we have ſaid concerning the evaporation and formation of the ſeveral ſalts in ſea-water, by deſcribing the method employed in the evaporation of the water of the ſalt-ſprings of Lorraine and Franche-compté.

This water is evaporated in very large veſſels made of plates of iron, capable of containing from eight to nine or ten thouſand gallons of water, called *ſalt-pans*, the depth of which is about fifteen or ſixteen inches.

In theſe the water is boiled ſome time, during which a ſaline earthy matter, called *ſchlot or ſcratch*, is depoſited, and is carefully to be ſeparated. This ſcratch is a ſelenites, which of all the ſaline matters contained in the water is the leaſt ſoluble, and conſequently cryſtallizes firſt. This ſelenites draws along with it ſome of the other ſalts, and principally Glauber's ſalt, which ſeems to have ſome degree of adheſion to it.

When the ſelenites is ſeparated, the common ſalt, being in greater quantity than the other ſalts, begins to cryſtallize and form cubes. That larger cryſtals of this ſalt may be formed, the water is made to boil very ſlowly, till the common ſalt ceaſes to cryſtallize. The water that remains is very heavy, much impregnated with ſalt, of an acrid and bitter taſte. This is the *mother-water*.

This mother-water contains ſtill ſome common ſalt, ſome Glauber's ſalt, and eſpecially a large quantity of marine ſalt with earthy baſis. The Glauber's

which is ſimilar to the ſalt obtained by evaporation of the mineral water at Epſom, is compoſed of vitriolic acid and magneſia; it is therefore improperly ſaid to be Glauber's ſalt, which conſiſts of vitriolic acid united with mineral alkali, although ſome of this latter ſalt alſo is ſaid to be contained in ſea-water.

 ſalt

ſalt remains chiefly in the mother-waters, becauſe it is much more ſoluble in hot than in cold water, and cryſtallizes more readily by cold than by evaporation. The marine ſalt with earthy baſis remains almoſt entirely in the mother-water, becauſe it is deliqueſcent, and not ſuſceptible of a true cryſtallization. *See* WATER (MOTHER).

The ſeveral ſalts contained in waters of ſalt-ſprings are thus ſeparated from each other: but this ſeparation is not very accurate. To render it more compleat, other means muſt be employed. The fundamental principles of the perfect purification of the ſeveral ſalts confounded together in the ſame water are explained at the article CRYSTALLIZATION. To avoid repetitions, we refer to that article. *See alſo the articles* SELENITES, SALT (COMMON), SALT *of* EPSOM, SALT *of* GLAUBER, SALT (MARINE) *with* EARTHY BASIS, WATER (MOTHER), *and* WATERS (MINERAL).

DCCXXXVI. WAX. Wax is an oily, concrete matter gathered by bees from plants.

Wax has been long conſidered as a reſin, from ſome properties common to it with reſins. It has the ſame conſiſtence as reſins have, and, like them, it furniſhes an oil and an acid by diſtillation, and is ſoluble in all oils: but in ſeveral reſpects it differs ſenſibly from reſins. Like theſe, wax has not a ſtrong aromatic taſte and ſmell, but a very weak ſmell, and, when pure, no taſte. With the heat of boiling water no principles are diſtilled from it; whereas, with that heat, ſome eſſential oil, or, at leaſt, a ſpiritus rector is obtained from every reſin. Further, wax is unſoluble in ſpirit of wine. If wax be diſtilled with a heat greater than that of boiling water, it may be decompoſed, but not ſo eaſily as reſins can. By this diſtillation a ſmall quantity of water is firſt ſeparated from the wax, and then ſome very volatile and very penetrating acid, accompanied with a ſmall quantity of a very fluid and very odoriferous oil. As the diſtillation advances, the acid becomes more and more ſtrong, and the oil more and more thick, till its conſiſtence be ſuch that it becomes ſolid in the receiver, and is then called *butter of wax*. When the diſtillation is finiſhed, nothing remains but a ſmall quantity of coal, which is almoſt incombuſtible from the want of ſome ſaline matter. *See* COAL.

Wax cannot be kindled, unleſs it be previouſly heated and reduced into vapors; in which reſpect it reſembles fat oils. The oil and butter of wax may, by repeated diſtillations, be attenuated and rendered more and more fluid, becauſe ſome portion of acid is thereby ſeparated from theſe ſubſtances; which effect is ſimilar to what happens in the diſtillation of other oils and oily concretes: but this remarkable effect attends the repeated diſtillation of oil and butter of wax, that they become more and more ſoluble in ſpirit of wine; and that they never acquire greater conſiſtence by evaporation of their more fluid parts. Boerhaave kept butter of wax in a glaſs veſſel open, or careleſsly cloſed, during twenty years, without acquiring a more ſolid conſiſtence. We may remark, that wax, its butter, and its oil, differ entirely from eſſential oils and reſins in all the above-mentioned properties, and that in all theſe they perfectly reſemble ſweet oils. *See* OILS (ESSENTIAL), RESINS, *and* OILS (SWEET EXPRESSED).

We may therefore conclude from what has been ſaid, as Mr. Macquer has done in his Elements of Chemiſtry, and in his Memoir upon Oils, that wax only

only resembles resins in being an oil rendered concrete by an acid; but that it differs essentially from these in the kind of the oil, which in resins is of the nature of essential oils, while in wax and in other analogous oily concretions, (as butter of milk, butter of cocoa, fat of animals, sperma-ceti, and a wax obtained from a tree in Louisiana) it is of the nature of sweet, unctuous oils that are not aromatic and not volatile, and are obtained from vegetables by expression.

Wax is very useful, especially as a better material than any other for candles.

Wax may be deprived of its natural yellow disagreeable color, and be perfectly whitened, by exposure to the united action of air and of water, by which method the color of many substances may be destroyed.

The art of bleaching wax consists in encreasing its surface. For which purpose, it must be melted with a degree of heat not sufficient to alter its quality, in a cauldron so disposed that the melted wax may flow gradually through a pipe at the bottom of the cauldron into a large tub filled with water, in which is fitted a large wooden cylinder, that turns continually round its axis, and upon which the melted wax falls. As the surface of this cylinder is always moistened with cold water, the wax falling upon it does not adhere to it, but quickly becomes solid and flat, and acquires the form of ribbands. The continual rotation of the cylinder carries off these ribbands as fast as they are formed, and distributes them through the tub. When all the wax that is to be whitened is thus formed, it is put upon large frames covered with linen cloth, which are supported about a foot and a half above the ground, in a situation exposed to the air, the dew, and the sun. The thickness of the several ribbands, thus placed upon the frames, ought not to exceed an inch and a half; and they ought to be moved from time to time, that they may all be equally exposed to the action of the air. If the weather be favorable, the color will be changed in the space of some days. It is then to be re-melted and formed into ribbands, and exposed to the action of the air as before. These operations are to be repeated till the wax be rendered perfectly white, and then it is to be melted into cakes, or formed into candles.

The yellow color of the wax is evidently destroyed by the combined action of the air, of the water, and of the sun. As the volatile, sulphureous acid has the property of destroying still more quickly almost all the colors of vegetables, perhaps this bleaching might be shortened by exposing ribbands of yellow wax to the vapor of sulphur, as is practised for wool and silk.

Every kind of wax is not equally capable of being whitened, the color of some adhering so strongly, that it cannot be effaced. Such is the wax that comes from countries in which vines grow. This observation I have received from Mr. Trudon, proprietor of the manufactory of wax, at Antoni, near Paris.

Wax is employed for many purposes in several arts. It is also used in medicine as a softening, emollient, and relaxing remedy; but it is only used externally, mixed with other substances. It is an ingredient in many pomatums, cerates, ointments, and plasters, to most of which it gives the due consistence. Upon this subject may be consulted Mr. Beaumé's Elements of Pharmacy, a work containing many excellent observations.

DCCXXXVII. W H E Y. *See* Milk.

DCCXXXVIII. W H I T E (S P A N I S H). This name is given to very different ſubſtances, namely, the *magiſtery of biſmuth*, and the waſhed *chalk* uſed for painting in water-colors.

DCCXXXIX. W H I T E - L E A D. This name is given to the white ruſt produced by expoſing lead to the vapors of vinegar. It is alſo called *ceruſs*. *See* Ceruss.

DCCXL. W I N E. Chemiſts give the name of *wine* in general to all liquors that have become ſpirituous by fermentation. Thus *cyder*, *beer*, *vinous hydromel*, or *mead*, and other ſimilar liquors, are wines.

The principles and theory of the fermentation which produces theſe liquors are eſſentially the ſame. The more general principles we have explained under the article Fermentation. At the articles Beer and Hydromel may be found ſome peculiarities relative to theſe kinds of wines. In the preſent article we ſhall chiefly attend to the *wine of grapes*, to which the name of *wine* is more particularly applied. At the ſame time, we ſhall not neglect any thing relating to ſpirituous fermentation in general.

All vegetable and animal matters, which have a taſte ſweet, agreeable, and more or leſs ſaccharine, and which are nutritive, are ſuſceptible of the ſpirituous fermentation. Thus wine may be made of all the juices of plants, the ſap of trees, the infuſions and decoctions of farinaceous vegetables, the milk of frugivorous animals, which is poſſeſſed of the above-mentioned qualities; and, laſtly, it may be made of all ripe ſucculent fruits, which alſo are poſſeſſed of theſe qualities: but all theſe ſubſtances are not equally proper to be changed into a good and generous wine.

As the production of ardent ſpirit is the reſult of the ſpirituous fermentation, we may conſider that wine as eſſentially the beſt which contains moſt of this ſpirit. But of all ſubſtances ſuſceptible of the ſpirituous fermentation, none is capable of being converted into ſo good wine, as the juice of the grapes of France, or of other countries that are nearly in the ſame latitude, or in the ſame temperature. The grapes of hotter countries, and even thoſe of the ſouthern provinces of France, do indeed furniſh wines that have a more agreeable, that is, more of a ſaccharine taſte; but theſe wines, though they are ſufficiently ſtrong, are not ſo ſpirituous as thoſe of the provinces near the middle of France: at leaſt, from theſe latter wines the beſt vinegar and aqua vitæ are made. As an example therefore of ſpirituous fermentation in general, we ſhall deſcribe the method of making wine from the juice of the grapes of France.

This juice, when newly expreſſed, and before it has begun to ferment, is called *muſt*, and in common language *ſweet wine*. It is turbid, has an agreeable and very ſaccharine taſte. It is very laxative, and when drank too freely, or by perſons diſpoſed to diarrhæas, it is apt to occaſion theſe diſorders. Its conſiſtence is ſomewhat leſs fluid than that of water, and it becomes almoſt of a pitchy thickneſs when dried.

When the muſt is preſſed from the grapes, and put into a proper veſſel and place, with a temperature from ten or twelve degrees to fifteen or ſixteen, very ſenſible effects are produced in it, in a ſhorter or longer time, according to the nature of the liquor, and the temperature of the place. It then ſwells, and is ſo rarefied, that it frequently overflows the veſſel containing it, if this be

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nearly full. An inteſtine motion is excited among its parts, accompanied with a ſmall hiſſing noiſe and evident ebullition. The bubbles riſe to the ſurface, and, at the ſame time, is diſengaged a vapor which is probably of a phlogiſtic nature, and is ſo ſubtle and dangerous, that it is capable of killing inſtantly men and animals expoſed to it in a place where the air is not renewed. In its effects this vapor is ſimilar to that of burning charcoal. The ſkins, ſtones, and other groſſer matters of the grapes, are buoyed up by the particles of diſengaged air that adhere to their ſurface, are variouſly agitated, and are raiſed in form of a ſcum or ſoft and ſpongy cruſt that covers the whole liquor. During the fermentation this cruſt is frequently raiſed, and broken by the air diſengaged from the liquor, which forces its way through it: afterwards the cruſt ſubſides, and becomes entire as before.

Theſe effects continue while the fermentation is briſk, and at laſt gradually ceaſe: then the cruſt being no longer ſupported, falls in pieces to the bottom of the liquor. At this time, if we would have a ſtrong and generous wine, all ſenſible fermentation muſt be ſtopt. This is done by putting the wine into cloſe veſſels, and carrying theſe into a cellar or other cool place.

After this firſt operation, nature tends ſpontaneouſly to a kind of reſt, as is indicated by the ceſſation of the ſenſible effects of the ſpirituous fermentation; and thus enables us to preſerve a liquor no leſs agreeable in its taſte, than uſeful for its reviving and nutritive qualities when drank moderately.

If we examine the wine produced by this firſt fermentation, we ſhall find that it differs entirely and eſſentially from the juice of grapes before fermentation. Its ſweet and ſaccharine taſte is changed into one that is very different, though ſtill agreeable, and ſomewhat ſpirituous and piquant. It has not the laxative quality of muſt, but affects the head, and occaſions, as is well known, drunkenneſs. Laſtly, if it be diſtilled, it yields, inſtead of the inſipid water obtained from muſt by diſtillation with the heat of boiling water, a volatile, ſpirituous, and inflammable liquor called *ſpirit of wine*, or *ardent ſpirit*. This ſpirit is conſequently a new being, produced by the kind of *fermentation* called the *vinous* or *ſpirituous*. *See* SPIRIT (ARDENT).

As, on one ſide, the liquors ſuſceptible of the ſpirituous fermentation contain chiefly a ſweet oil rendered miſcible with water by means of an acid; and as, on the other ſide, the liquor produced by the ſpirituous fermentation is inflammable, but ſtill miſcible with water, and conſequently compoſed of a watery and inflammable principle; we may eaſily perceive, that the work of nature chiefly conſiſts in attenuating, dividing, and volatiliſing the oily parts of fermentable matters, and in combining theſe intimately with the watery principle. But by what mechaniſm does nature operate this change? In what does this attenuation of the oily part preciſely conſiſt? In what proportion is this oil, or only its inflammable principle, united with the watery principle in the compoſition of ardent ſpirit? Theſe are myſteries of nature that are ſtill entirely hid from us, and which we cannot eaſily explain. Without entering, therefore, into a ſpeculation concerning the production of ardent ſpirit, we ſhall proceed in the hiſtory of ſpirituous fermentation.

When any liquor undergoes the ſpirituous fermentation, all its parts ſeem not to ferment at the ſame time, otherwiſe the fermentation would probably be very quickly compleated, and the appearances would be much more ſtriking:

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hence, in a liquor much diſpoſed to fermentation, this motion is more quick and ſimultaneous than in another liquor leſs diſpoſed. Experience has ſhewn, that a wine, the fermentation of which is very ſlow and tedious, is never good and very ſpirituous; and therefore, when the weather is too cold, the fermentation is uſually accelerated by heating the place in which the wine is made. A propoſal, which I think is a good one, has been made by a perſon very intelligent in economical affairs, to employ a greater than the uſual heat to accelerate the fermentation of wine, in thoſe years in which grapes have not been ſufficiently ripened, and when the juice is not ſufficiently diſpoſed to fermentation.

A too haſty and violent fermentation is perhaps alſo hurtful, from the diſſipation and loſs of ſome of the ſpirit: but of this we are not certain. However, we may diſtinguiſh, in the ordinary method of making wines of grapes, two periods in the fermentation, the firſt of which laſts during the appearance of the ſenſible effects above-mentioned, in which the greateſt number of fermentable particles do ferment. After this firſt effort of fermentation, theſe effects ſenſibly diminiſh, and ought to be ſtopped, for reaſons hereafter to be mentioned. The fermentative motion of the liquor then ceaſes. The heterogeneous parts that were ſuſpended in the wine by this motion, and which render it muddy, are ſeparated, and form a ſediment called the lees; after which the wine becomes clear: but although the operation be then conſidered as finiſhed, and the fermentation apparently ceaſes, it does not really ceaſe; and it ought to be continued in ſome degree, if we would have good wine. In this new wine a part of the liquor remains that has not fermented, and which does afterwards ferment, but ſo very ſlowly, that none of the ſenſible effects produced in the firſt fermentation are here perceived. The fermentation, therefore, continues ſtill in the wine, during a longer or ſhorter time, although in an imperceptible manner; and this is the ſecond period of the ſpirituous fermentation, which may be called the *imperceptible fermentation*. We may eaſily perceive, that the effect of this imperceptible fermentation is the gradual encreaſe of the quantity of ſpirit in wine. It has alſo another effect no leſs advantageous, namely, the ſeparation of a ſaline, acid, earthy matter, called *tartar*, from the wine. This matter is therefore a ſecond ſediment that is formed in the wine, and which adheres to the ſides of the containing veſſels. As the taſte of tartar is harſh and diſagreeable, it is evident that the wine, which, by means of the inſenſible fermentation, has acquired more ſpirit, and has diſengaged itſelf of the greateſt part of its tartar, ought to be much better and more agreeable; and for this reaſon chiefly, old wine is univerſally preferable to new wine.

But inſenſible fermentation can only ripen and meliorate the wine, if the ſenſible fermentation has regularly proceeded, and has been ſtopped in due time. We know certainly, that if a ſufficient time has not been allowed for the firſt period of the fermentation, the unfermented matter that remains, being in too large a quantity, will then ferment in the bottles or cloſe veſſels in which the wine is put, and will occaſion effects ſo much more ſenſible, as the firſt fermentation ſhall have been ſooner interrupted: hence theſe wines are always turbid, emit bubbles, and ſometimes break the bottles, from the large quantity of air and vapors that are diſengaged during the fermentation. We have an inſtance of theſe effects in the white wine of Champagne, and in others of the

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ſame kind. The ſenſible fermentation of theſe wines is interrupted, or rather ſuppreſſed, that they may have this ſparkling quality. It is well known that theſe wines make the corks fly out of the bottles, that they ſparkle and froth when they are poured into glaſſes, and, laſtly, that they have a taſte much more lively and more piquant than wines that do not ſparkle; but this ſparkling quality, and all the effects depending on it, are only cauſed by a conſiderable quantity of air which is diſengaged during the confined fermentation which the wine has undergone in cloſe veſſels. This air, not having an opportunity of eſcaping, and of being diſſipated as faſt as it is diſengaged, and being interpoſed betwixt all the parts of the wine, combines in ſome meaſure with theſe, and adheres in the ſame manner as it does to thoſe mineral waters that are called ſpirituous, in which it produces nearly the ſame effects. When this air is entirely diſengaged from theſe wines, they no longer ſparkle, they loſe their piquancy of taſte, become mild, and even almoſt inſipid.

Such are the qualities that wine acquires in time, when its firſt fermentation has not continued ſufficiently long. Theſe qualities are given purpoſely to certain kinds of wine, to indulge taſte or caprice; but ſuch wines ought not to be daily drank. Wines for daily uſe ought to have undergone ſo compleatly the ſenſible fermentation, that the ſucceeding fermentation ſhould be inſenſible, or, at leaſt, exceedingly little ſenſible. Wine, in which the firſt fermentation has been too far advanced, is liable to worſe inconveniences than that in which the firſt fermentation has been too quickly ſuppreſſed; for every fermentable liquor is from its nature in a continual fermentative motion, more or leſs ſtrong, according to circumſtances, from the firſt inſtant of the ſpirituous fermentation, till it is compleatly putrefied: hence from the time of the completion of the ſpirituous fermentation, or even before, the wine begins to undergo the acid or acetous fermentation. This acid fermentation is very ſlow and inſenſible when the wine is included in very cloſe veſſels, and in a cool place; but it does gradually advance, ſo that in a certain time the wine, inſtead of being meliorated, becomes at laſt ſour. This evil cannot be remedied, becauſe the fermentation may advance, but cannot be reverted. Wine-merchants, therefore, when their wines become ſour, can only conceal or abſorb this acidity by certain ſubſtances, as by alkalis and abſorbent earths. But theſe ſubſtances give to wine a dark-greeniſh color, and a taſte, which, though not acid, is ſomewhat diſagreeable. Beſides, calcareous earths accelerate conſiderably the total deſtruction and putrefaction of the wine. Calxes of lead, having the property of forming with the acid of vinegar a ſalt of an agreeable ſaccharine taſte, which does not alter the color of the wine, and which beſides has the advantage of ſtopping fermentation and putrefaction, might be very well employed to remedy the acidity of wine, if lead and all its preparations were not pernicious to health, as they occaſion moſt terrible colics, and even death, when taken internally. We cannot believe that any wine-merchant, knowing the evil conſequences of lead, ſhould, for the ſake of gain, employ it for the purpoſe mentioned; but if there be any ſuch perſons, they muſt be conſidered as the poiſoners and murderers of the public.

If wine contains litharge, or any other calx of lead, it may be diſcovered by evaporating ſome pints of it to dryneſs, and melting the reſiduum in a crucible, at the bottom of which a ſmall regulus of lead may be found after the fuſion:

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but an easier and more expeditious proof is by pouring into the wine some liquid liver of sulphur. If the precipitate occasioned by this addition of the liver be white, or only colored by the wine, we may know that no lead is contained: but if the precipitate be dark-colored, brown, or blackish, we may be certain that lead is contained.

The only substances that cannot absorb or destroy, but cover and render supportable the sharpness of wine, without any inconvenience, are sugar, honey, and other saccharine alimentary matters; but they can succeed only when the wine is but very little acid; and when an exceeding small quantity only of these substances is sufficient to produce the desired effect; otherwise the wine would have a sweetish, tart, and not agreeable taste.

From what we have said concerning the acescency of wine we may conclude, that when this accident happens, it cannot by any good method be remedied, and that nothing remains to be done with sour wine but to sell it to vinegar-makers, as all honest wine-merchants do. We may observe, that the first sensible fermentation having been too far advanced, is not the only cause of the acidity of wine, but that heat also is capable of producing the same effect. Thus wine, which might have been long preserved in a cool place, very quickly becomes sour, when placed in a bad cellar; and even as the best cellars have during winter a degree of heat much superior to that of the atmosphere, it would be very proper, when wine disposed to become sour is to be preserved, to bring it from the cellar in the beginning of winter, and leave it exposed to the air during all that season.

Wine is also liable to other changes; as, to become ropey and mucilaginous, by the continuance of the fermentative motion: but we cannot prosecute these details in a work of this kind. Besides, the spirituous fermentation and its consequences still require a further examination, which we hope will be performed in a satisfactory manner, since several Academies, sensible of the importance of the subject, have offered prizes for discoveries relative to it. All that we can at present say is, that the fundamental principles from which we may deduce a more accurate knowledge on this subject, may be discovered by determining with what degree of heat, and during what time, the first sensible fermentation of must ought to be promoted, that the most spirituous and best-keeping wine may be obtained. I confess that this object is very extensive, and very difficult to be known in a general manner, considering how variable these things are, and what differences, perhaps greater than we now imagine, there ought to be, according to the nature of the must, which varies exceedingly in different countries, and at different times. Experience and observation have already instructed makers of wine in many things relative to this subject; but much yet remains to be determined, which is not within the reach of ordinary country-people, or even of the proprietors of the great vine-yards.

Wine, and the matters produced from wine, as brandy, spirit of wine, vinegar, lees of wine, tartar, are greatly and extensively useful. The lees of wine are employed in the manufacture of hats. These lees, and also tartar by incineration, yield a larger quantity than any other vegetable matter of pure fixed alkali. *See the articles* AQUA VITÆ, SPIRIT *of* WINE, TARTAR, *and* VINEGAR.

Wine has been preferred in all times and in all countries to every other alimentary liquor. We may ſay in general, that it is good and ſalutary when taken in ſmall quantities, and that it is pernicious when drank habitually, and in too large quantities. Wine becomes then a true ſlow poiſon, which is ſo much more dangerous, as it is more agreeable. But if we obſerve more particularly the effects of wine, we ſhall perceive very great differences depending on different conſtitutions. Some perſons drink habitually large quantities of pure wine, without any ſenſible inconvenience, or diſeaſe, or ſhortening their lives: but, on the contrary, many others do alſo entirely deſtroy their health, and ſhorten their lives, by an habitual uſe of wine even in ſmall quantity, and mixed with water. Although it is always more ſafe and prudent for every perſon to drink little of it habitually, this moderation is more indiſpenſably neceſſary to thoſe whoſe conſtitutions wine does not ſuit.

As the diſeaſes conſequent upon the too free uſe of wine come gradually and inſenſibly, ſometimes even during many years, ſeveral perſons, eſpecially men, otherwiſe very ſober and attentive to health, are every day deceived upon this article, drinking more wine than is ſuitable to their conſtitution, and gradually ruining their health without knowing the cauſe. It is therefore a matter of importance to ſhew the ſigns by which wine may be known to be hurtful. We may know that wine does not ſuit a perſon, when, after drinking moderately of it, his breath acquires a vinous ſmell; when it occaſions ſour belchings and ſlight pains in the head; and when, after drinking it more copiouſly than uſual, it produces ſtupefaction, nauſea, and drunkenneſs, eſpecially when this drunkenneſs is of the moroſe, peeviſh, quarrelſome, and iraſcible kind. Unhappy is that perſon who ſuffers theſe effects from wine, and notwithſtanding contracts and perſiſts in the habitual uſe of it. Theſe imprudent perſons do never fail of coming to a miſerable death, preceded by languor, and premature; their common age being about fifty years, or a little more. The diſeaſes to which they are moſt ſubject are obſtructions in the liver, in the meſenteric glands, and in other abdominal viſcera, which are almoſt always ſucceeded by an incurable dropſy. Thoſe who digeſt wine well, do not ſuffer, or much leſs ſenſibly, the above-mentioned effects of drinking it. Their drunkenneſs is accompanied with vivacity and joy. Such perſons ſeldom die of the obſtructions and dropſy above-mentioned: but wine is nevertheleſs ſo much more dangerous to them, that as they ſuffer none of the diſagreeable effects, they are more liable to contract the habit of drinking too much. Drinkers of this claſs generally live ſomewhat longer than the former; but their conſtitution generally changes before ſixty years of age; and the inheritance of their old age is either a ſevere gout or palſy, ſtupidity, imbecillity, or an accumulation of theſe diſeaſes.

We need not mention that the too frequent uſe of brandy, ratafia, and of other ſpirituous liquors is ſtill much more pernicious and fatal than of wine.

Wine is uſed in medicine as a vehicle in the compoſition of many internal and external remedies. As wine is compoſed of an ardent ſpirit, water, extractive ſaponaceous matter, and acid of tartar, it may be very uſefully employed for the extraction of almoſt all the proximate principles, and conſequently of the medicinal parts, of vegetables. Many extracts are made with wine, which may be conſidered as being more compleat than thoſe made with water: but phyſicians who preſcribe theſe extracts ought to remember that, beſides

the principles of the vegetables, they alſo contain the extractive part of wine, that is, all the principles of wine, excepting the ardent ſpirit, which is too volatile to remain in an extract.

As wine, when good, may be preſerved during a long time, ſeveral medicinal wines preſcribed in diſpenſatories are kept in the ſhops of apothecaries. Such are the aſtringent, antiſcorbutic, febrifugal wines of the Peruvian bark, of wormwood, chalybeate wine, and others. In many caſes, as in ſeveral chronical diſeaſes, where tonic, cordial, fortifying and exciting remedies are indicated, phyſicians prefer the uſe of wine to water, as a vehicle for the infuſion of purgative, aperitive, and other medicinal ſubſtances.

DCCXLI. WOAD. (z)

(z) Woad. Dr. Lewis in a note to his edition of Neuman's Chemical Works gives the following account of woad.

Woad, *iſatis*, *glaſtum*, is a plant with long green leaves; the lower ones narrow at both ends; thoſe which grow upon the ſtalk are broad at bottom like an arrow-head. On the tops come forth numerous yellow flowers, which are followed by little flat pods containing the ſeeds. It grows wild in ſome parts of France, and on the coaſts of the Baltic Sea: the wild woad, and that which is cultivated for the uſe of dyers, appear to be the ſame ſpecies of plant. The preparation of woad for dying, as practiſed in France, is minutely deſcribed by Aſtruc, in his Memoirs for a Natural Hiſtory of Languedoc. The plant puts forth at firſt five or ſix upright leaves, about a foot long and ſix inches broad: when theſe hang downwards, and turn yellow, they are fit for gathering: five crops are gathered in one year. The leaves are carried directly to a mill, much reſembling the oil or tan-mills, and ground into a ſmooth paſte. If this proceſs was deferred for ſome time, they would putrefy, and ſend forth an inſupportable ſtench. The paſte is laid in heaps, preſſed cloſe and ſmooth, and the blackiſh cruſt, which forms on the outſide, reunited if it happens to crack: if this was neglected, little worms would be produced in the cracks, and the woad would loſe a part of its ſtrength. After lying for fifteen days, the heaps are opened, the cruſt rubbed and mixed with the inſide, the matter formed into oval balls, which are preſſed cloſe and ſolid in wooden moulds. Theſe are dried upon hurdles: in the ſun, they turn black on the outſide; in a cloſe place, yellowiſh, eſpecially if the weather be rainy: the dealers in this commodity prefer the firſt, though it is ſaid the workmen find no conſiderable difference betwixt the two. The good balls are diſtinguiſhed by their being weighty, of a pretty agreeable ſmell, and when rubbed, of a violet colour within. For the uſe of the dyer, theſe balls require a further preparation: they are beat with wooden mallets, on a brick or ſtone floor, into a groſs powder; which is heaped up in the middle of the room to the height of four feet, a ſpace being left for paſſing round the ſides. The powder, moiſtened with water, ferments, grows hot, and throws out a thick fetid fume. It is ſhovelled backwards and forwards, and moiſtened every day for twelve days; after which it is ſtirred leſs frequently, without watering, and at length made into a heap for the dyer.

The powder thus prepared gives only browniſh tinctures, of different ſhades, to water, to rectified ſpirit of wine, to volatile alkaline ſpirits, and to fixed alkaline lixivia: rubbed on paper, it communicates a green ſtain. On diluting the powder with boiling water, and after ſtanding ſome hours in a cloſe veſſel, adding about one twentieth part of its weight of lime newly ſlaked, digeſting in a gentle warmth, and ſtirring the whole together every three or four hours, a new fermentation begins, a blue froth ariſes to the ſurface, and the liquor, though it appears itſelf of a reddiſh color, dyes woollen of a green, which, like the green from Indigo, changes in the air to a blue. This is one of the niceſt proceſſes in the art of dyeing, and does not well ſucceed in the way of a ſmall experiment.

Aſtruc propoſes the manufacturing of freſh woad leaves in Europe, after the ſame manner as the Indigo plant is manufactured in America;

DCCXLII. W O L F R A M. (*a*)

DCCXLIII. W O O L (P H I L O S O P H I C). This is a name given by ancient chemical or alchemical authors to flowers of zinc. *See* FLOWERS *of* ZINC.

DCCXLIV. W O R M W O O D. (*b*)

America; and thus preparing from it a blue fecula similar to indigo, which from his own experiments he has found to be practicable. Such a management would doubtless be accompanied with some advantages, though possibly, woad so prepared might lose those qualities which now render it, in a large business, preferable on some accounts to indigo, as occasioning greater dispatch when once the vat is ready, and giving out its color less hastily, so as to be better fitted for dying very light shades.

(*a*) WOLFRAM, *Spuma lupi*, is a very refractory mineral of a black or dusky color, crystallized in form of cubes, striæ, or other determinate shape, and consisting of shining plates. Its appearance is similar to the ore of tin, called tin-grains or crystals of tin: and it is frequently found in tin-mines. It is so hard that it can strike sparks from steel. When powdered, it is red. Wallerius considers it as an ore of iron mineralised by arsenic, which sometimes contains tin. According to Cronstedt, it is a kind of magnesia or manganese, containing a small portion of iron and of tin.

(*b*) WORMWOOD. The leaves of wormwood are intensely bitter, and have a strong smell, somewhat of the aromatic kind. They yield in distillation a considerable quantity of essential oil of a dark greenish color possessing the whole of their smell, the bitter matter remaining in the extract. *Neuman*.

Z.

DCCXLV. ZAFFRE, *or* SAFFRE. Zaffre is the residuum of cobalt, after the ſulphur, arſenic, and other volatile matters of this mineral have been expelled by calcination. It is therefore a kind of calx of cobalt, of a grey or reddiſh color. The uſe of cobalt is to produce a very fine blue color, when it is melted with fuſible and vitrifiable matters.

This blue color produced by the vitrification of zaffre proceeds from the earth or calx of a ſemi-metallic ſubſtance contained in cobalt, called by chemiſts, *regulus of cobalt*. This is proved by melting zaffre with a reducing flux, like any other roaſted ore; by which means the above-mentioned ſemi-metallic regulus of cobalt will be obtained. The ſcoria in this fuſion has alſo a blue color, which proceeds from a portion of the calx of this regulus that is not reduced, but is vitrified along with the ſcoria.

The calx therefore or metallic earth of the regulus of cobalt is the ſole cauſe of the blue color produced by zaffre. But as the quantity of regulus contained in cobalt is variable, therefore ſome zaffres furniſh more blue than others. The heterogeneous, fixed matters contained in cobalts, contribute, according to their quantity, not only to the greater or leſs intenſity of the blue color, but alſo to its luſtre and beauty. For which reaſon thoſe who manufacture zaffre from cobalt make frequent eſſays of the roaſted ore by mixing it with vitreous matters to diſcover the intenſity and beauty of the blue color.

Good cobalts calcined would form too deep a blue, and almoſt a black glaſs, if they were not previouſly mixed with a certain quantity of vitreous fritt. In the manufacture of zaffre, therefore, the calx of cobalt, the ſtrength of which has been previouſly determined by Eſſays, is mixed with ſuch a quantity of ſand, or of powdered flints and quartz, that with the addition of ſome ſaline flux, a deep blue glaſs may be formed.

The zaffre that is commonly ſold, and which comes from Saxony, is a mixture of calx of cobalt with ſome vitrifiable earth, as we have ſaid. It is of a grey color,

color, as all calxes of cobalt are before vitrification. Some zaffres are dearer than others, according to the intensity of the color which they are capable of producing. Zaffre is employed in the manufacture of pottery and of porcelain, for painting the surface of the pieces of ware, upon which it is applied together with some saline flux, previously to the baking or glazing, that the same fire may also vitrify this coloring material.

The blue of zaffre is the most solid and fixed of all the colors that can be employed in vitrification. It suffers no change from the most violent fire. It is successfully employed to give shades of blue to enamels, and to the crystal-glasses made in imitation of some opake and transparent precious stones, as the lapis lazuli, the turquois, the saphire, and others of this kind. *See the articles* AZURE, COBALT, INK (SYMPATHETIC), *and* SMALT.

DCCXLVI. ZEOLITES. (*c*)

DCCXLVII. ZINC. Zinc is a semi-metal, of a brilliant white color, approaching to blue. It is the least brittle of the semi-metals; and when well furnished with phlogiston, which may be effected by treating it with inflammable matters in a close vessel, it possesses a semi-ductility, by means of which it may be flattened into thin plates. (*d*).

This property, joined to its hardness, which is also considerable, renders it incapable of being pulverised like the other semi-metals; therefore, when it is required in a divided state, it must be melted and granulated, or filed, like metals.

(*c*) ZEOLITES. This name is given by Mr. Cronstedt to a stone described by him in the *Transactions of the Academy of Sciences at Stockholm for the year* 1756, the peculiar properties of which have induced that mineralogist to consider it as forming a distinct order of earths, called *zeolites*. The properties of this stone or class of earths, are the following.

1. It is a little harder than the fluors, and calcareous spars. It may be scratched by steel, from which it does not elicit sparks.

2. It may easily be melted by heat without addition, into a white frothy slag, which not without great difficulty can be rendered solid and transparent. Crystallized zeolites, when melted, boils, as borax does.

3. It may be dissolved in the fire more easily by mineral alkali than by borax or by the fusible salt of urine.

4. It does not effervesce with the fusible salt of urine, as calcareous stones do; nor with borax, as gypseous stones do.

5. It dissolves very slowly, and without effervescence, in acids, as in oil of vitriol, and spirit of nitre. When concentrated vitriolic acid is poured on powdered zeolites, a heat arises, and the powder is changed into a gelatinous mass.

6. In the very moment of fusion it gives a phosphoric light.

Zeolites has been found only in an indurated state. It is either, 1. consisting of particles of no determinate form; or, 2. *sparry*; or, 3. *crystallized*.

The zeolites that consists of particles of no determinate form, is either *pure*, and white; or it is *mixed with silver and iron*; which latter kind is of a blue color, and is commonly called lapis lazuli. *See* LAPIS LAZULI.

The *sparry zeolites* resembles calcareous spar, but is more brittle. This is of a light red, or orange color.

Crystallized zeolites. Groupes of crystals of zeolites are found in form of white or yellow balls consisting of many pyramids the apices of which unite in the center; or of white prisms with truncated angles; or of white capillary crystals.

Zeolites has in the fire nearly the same properties as boles have. See *Stockholm Trans.* for the year 1755, and *Cronstedt's Mineralogy*, §. 108.

(*d*) Zinc when broken appears of many flat, shining plates, or facets, which are larger when slowly than when hastily cooled.

When

The ſpecific gravity of zinc is nearly the ſame as that of regulus of antimony; that is to ſay, it loſes in water about a ſeventh part of its weight. (*e*)

This ſemi-metal is not eaſily calcined or covered with ruſt by the action of the air and of water: in this reſpect it reſembles tin. It is leſs fuſible than tin and lead, as it does not melt till it is almoſt red-hot. When it only ſuffers the degree of heat neceſſary for its fuſion, its ſurface is calcined and reduced to a grey calx, eaſily reducible, like thoſe of tin and other fuſible metallic ſubſtances. But when it is expoſed to heat approaching to a white-heat, it flames; and during this inflammation it exhibits a very beautiful and ſtriking appearance. The flame of zinc is infinitely more lively, more luminous, and more brilliant, than the flame of any other inflammable matter. It is of a dazzling white, and is ſo vivid as to be inſupportable to the ſight. This flame cannot be attributed to any ſulphur which might be ſuppoſed to remain united with the zinc, for we ſhall ſee that this ſemi-metal cannot be united with ſulphur; but merely to phlogiſton, which in zinc is very combuſtible. This ardent deflagration is a moſt ſenſible proof of the preſence of this principle in metallic ſubſtances.

The deflagration of zinc is ſo violent that the earth of this ſemi-metal although naturally very fixed, like that of almoſt all metallic ſubſtances, is raiſed in form of white ſmoke, which is condenſed, and floats in the air like light flocks. Theſe are called *flowers of zinc*, and *philoſophical wool*. *See* FLOWERS *of* ZINC.

Zinc being the moſt combuſtible of all metals, detonates more violently than any other metal with nitre. From the whiteneſs and brilliancy of the flame produced by this detonation, it has been employed with very good effect as an ingredient in compoſitions for fireworks.

All acids are capable of diſſolving zinc. Six parts of good vitriolic acid diluted with an equal weight of water can diſſolve entirely, by help of gentle heat, one part of zinc. The neutral ſalt reſulting from this ſolution is cryſtallizable; and is called *white vitriol*, or *vitriol of zinc*. See a deſcription of the method in which this vitriol is made at Goſlar, at the article SMELTING *of* ORES.

Zinc has a ſtrong affinity with vitriolic acid. It appears to have a ſtronger than any other metallic ſubſtance: for by means of this ſemi-metal, the vitriols of copper and of iron may be decompoſed. It ſeparates theſe metals from the vitriolic acid, to which it unites and forms a white vitriol. But what is remarkable, is, that notwithſtanding this great affinity of zinc with vitriolic acid, the vitriol of zinc is decompoſed, and its acid ſeparated by leſs heat than the martial vitriol, as Junker affirms in the firſt volume of his *Conſpectus Chymiæ*. If this experiment ſucceeds, as probably it does, we muſt refer the cauſe of it to the particular ſtates of the inflammable principle in zinc and in iron. All the properties of theſe two metallic ſubſtances ſhew that they abound in phlogiſton, and therefore vitriolic acid unites with them preferably to any other. But, at the ſame time, this phlogiſton is in theſe metals much

When heated, it is very brittle. Like tin, it makes a crackling noiſe when it is bent.

(*e*) According to Muſchenbroek's table of ſpecific gravities, Indian zinc is to water as 7.2401 to 1: and zinc of Goſlar is as 7.215 to 1.

unfolded

unfolded and weakly combined, which is undoubtedly the cauſe, that the neutral ſalts which they form with the vitriolic acid may be decompoſed by the action of fire. For, the phlogiſton of theſe metals adhering but ſlightly to their earth, may be more eaſily combined with the vitriolic acid, and by converting this acid into volatile vitriolic, or ſulphureous acid, may ſtill more facilitate its ſeparation.

But as the inflammable principle of zinc is more abundant, and more ſlightly engaged than that of iron, zinc ought to unite with vitriolic acid preferably to iron, and the vitriol of zinc ought to be decompoſed by fire more eaſily than the vitriol of iron.

When white vitriol is diſtilled by violent heat, nearly the ſame phenomena happen as when martial vitriol is diſtilled. Towards the end of the diſtillation of white vitriol, a vitriolic acid ariſes, dephlegmated, tho' very ſulphureous. This acid added to common concentrated vitriolic acid produces as much heat as water would have done, if added to the ſame concentrated acid.

Zinc may alſo be diſſolved in the nitrous and marine acids. But this latter acid does not touch a black matter which ſeparates from the ſemi-metal during its ſolution. M. Hellot who has examined the phenomena of this ſolution as well as thoſe of the ſolutions of this ſemi-metal in the vitriolic and nitrous acids, has aſcertained that this black matter is not mercury, and that it cannot even be reduced into a metallic ſubſtance. (*f*)

Zinc may be allayed or mixed with all metallic ſubſtances excepting *biſmuth* (*g*). If theſe two metals be melted together, they will be found ſeparately at the bottom of the crucible, the zinc being the lighter lying above the biſmuth. The allay of zinc with iron is effected difficultly; but that with copper ſucceeds well, and is much uſed, on account of a ſingular property which zinc has of uniting with copper in a conſiderable proportion; as, for inſtance, one part of zinc to four or three parts of copper, without much diminution of the ductility of the copper. Zinc added to copper renders this metal leſs ſubject to ruſt, and gives to it a yellow color reſembling that of gold. This copper ſo allayed with zinc is called *braſs* or *latten*. *See* BRASS.

The color of braſs approaching to that of gold, has induced chemiſts to ſearch for the means of communicating to copper the true color of gold. And they have actually ſucceeded in the compoſitions or allays called *tombacs*, *ſimilor*, *Pinchbeck*, and *Prince's metal*. Beccher had ſaid, that equal parts of copper and zinc mixed together gave a color to the touch-ſtone like that of the gold from the Rhine. Stahl remarks that the proportion of zinc mentioned by Beccher is too great, but does not determine what this proportion ought to be. Since that time, the due proportion has been inveſtigated, and ſeveral fine imitations of gold have been found. The Engliſh were the firſt who ſucceeded, and they called their invention *Prince's metal*, or *Prince Rupert's metal*.

More perfect imitations of gold have been lately made by Lacroix and Leblanc; each of whom produced a metallic mixture, one of which excelled in

(*f*) Neuman ſays, that this black matter was ſeparated during the ſolution of this ſemi-metal in vitriolic and in marine acids, and that two or three days afterwards it was re-diſſolved.

(*g*) It cannot be allayed with the ſemi-metal called nickel.

ductility,

ductility, and the other in color. But these artists have not revealed their processes. M. Geoffroy has made with this view many experiments, the detail of which may be seen in the Memoirs of the Academy for the year 1725. It appears from these experiments, that the remark made by Stahl, that an equal quantity of zinc is too much, was very just, with regard to the ductility of the allay, but that equal quantities produced the finest color. We may nevertheless observe, that as copper requires a strong heat to keep it fused, and as zinc is very volatile, these two substances cannot be mixed without loss, both of the copper, some of which is calcined, and of the zinc, a part of which is burnt and dissipated in fumes. Hence it follows, that after the mixture is made, the proportion betwixt the two metals is not certain. After some experiments which I have seen, I can scarcely be persuaded that a fine-colored mixture can be obtained, and particularly of a deep enough yellow, if as much zinc as copper actually remained. *(b)*

We must also observe, that in order to have a fine-colored and ductile metallic mixture of this kind, it is necessary, according to Mr. Cramer, to use the purest zinc. The same author shews the means of purifying it, and of ascertaining its purity. This method is founded on the remarkable property which zinc has of being incapable of uniting with sulphur *(i)*. Therefore, to purify this semi-metal from the allay of other metals, it is necessary to throw upon it, when melted in a large crucible, suet and sulphur alternately, and the latter in larger quantities than the former. If the zinc is pure, the sulphur burns freely on its surface; but if it is allayed, the sulphur combines with the other metals, and forms with them a kind of scoria which must be taken off. This alternate projection of suet and sulphur upon zinc is continued till the sulphur be burnt on the surface of the melted zinc, without forming any scoria; the zinc thus purified, may be successfully employed for making of brass or metallic mixtures in imitation of gold.

The affinities of zinc are, according to Mr. Gellert's table, in the following order: Copper, iron, silver, gold, tin, and lead. This last is said to be only partly miscible with zinc. Sulphur might be so placed in this table, as to shew its incapacity of uniting with zinc.

The chief use of zinc is as an ingredient in the composition of brass. M. Malouin, who, in his Memoirs upon Zinc, has mentioned several properties of this semi-metal which he finds analogous to those of tin, relates in these Memoirs some experiments which he made with success, in order to substitute zinc for tin, in the operation upon iron plates, &c. called *tinning*. As all the properties

(b) One part of zinc is said to be capable of destroying the ductility of a hundred parts of gold. An allay of equal parts of zinc and gold is very hard, white, capable of receiving a fine polish, and not subject to rust or tarnish: hence it is proposed by Mr. Malouin as a good material for making specula of telescopes. Zinc gives hardness to tin, and is therefore added in some compositions for making pewter.

(i) Mr. Cramer says that zinc does not easily unite with sulphur, but that if it remains long in a moderate fire, and be covered over with sulphur at several times, and continually stirred with a poker, it will be at last changed into a very brittle, dark-colored substance. I suspect that the iron of the poker contributed to this union of zinc with sulphur, for I have never been able to unite sulphur with pure zinc, when I stirred them with a tobacco-pipe.

of this ſemi-metal are not yet diſcovered, it may perhaps be hereafter found applicable to other uſes. (*k*)

(*k*) Some authors, as Wallerius and Cronſtedt, ſay, that filings of zinc are attracted by magnets. I have not been able to obſerve this property.

Zinc unites more ſtrongly to acids than any other metal, and even ſome earths. Mr. Pott ſays, that it precipitates the earthy baſes from a ſolution of alum; and that zinc cannot be precipitated from aqua fortis by crabs-eyes. He alſo ſays, that it may be precipitated by volatile alkali, but that this precipitate is quickly re-diſſolved.

The ſame author ſays, that zinc, by being converted into flowers, acquires an additional weight, equal to $\frac{1}{10}$th part of the ſemi-metal employed.

Mr. Malouin relates, that zinc being melted ſix times, and the fuſion continued 15 hours each time, it became more and more hard, brittle, unfuſible, and uncalcinable. He ſays, that its color became grey after the ſecond fuſion, brown after the third, black after the fourth, blue like a ſlate after the fifth, and a clear violet-color after the ſixth.

Concerning the ores and eſſay of ores of zinc, *ſee* Ores *of* Zinc; and concerning the methods of extracting large quantities of this ſemi-metal from its ores, *ſee* Smelting *of* Ores, and Plate II. *Fig.* 15, and 22, with the explanations.

F I N I S.

CORRECTIONS AND ADDITIONS.

CORRECTIONS AND ADDITIONS.

PAGE 2. *Notes, column second, line fourth.* Instead of, "them with a certain "quantity of water," read, "concentrated acids with a certain quantity "of water or of ice."

Page 3. *Notes, column first, line* 14. Instead of, "they," read, "most, if "not all of them, when much concentrated."

Ibid. col. 2, *line* 31. Instead of, "of solid acid in each neutral salt," read, "that "each neutral salt retains of the acid liquor employed in its preparation."

Page 4. *Notes, col.* 1, *line* 4. Instead of "shall," read, "should."

Ibid. line 8. Instead of, "Hence we may perceive, &c." *to the end of the sentence*; read, "But as a less quantity of acid was said to have been actually employed, "Mr. Homberg's alkali must have contained a less quantity of fixable air than "we have supposed. But as we do not know the precise quantity of that air, "nor the degree of dryness of his alkaline salt, we cannot from his experiments "ascertain the quantity of pure, dry, caustic alkali, contained in any of the "neutral salts produced; nor can we determine how much of the acid liquor "employed was retained in those neutral salts after they had crystallized."

Page 9. *Notes, col.* 2. *line* 8. Instead of, "but not volatile alkali," read, "but it does not render volatile alkali soluble in spirit of wine."

Page 33. *Note* (*b*), *line* 1. Instead of, "term," read, "name."

Ibid. Notes, col. 2, *line* 1. Instead of, "this," read, "his."

Page 34. *Notes, col.* 1, *line penult.* Instead of, "combined," read, "uncombined."

Page 35. *Notes, col.* 2. After the 28th line add, "Dr. Macbride shews, that the "air extricated from fermenting and putrefying substances is capable of com- "bining with caustic alkalis, and with quicklime, and of rendering these mild. "This air is therefore probably of the same kind as the air usually combined "with alkaline substances."

Page 37. *Notes, col.* 1. After the second line, add, "Concerning the fixable "air contained in *mineral waters*, and its power of *dissolving calcareous earth*; "and *iron* contained in these waters, *see the article* WATERS (MINERAL), *and* "*a Note subjoined.*"

Page 40. Add the following *note*, referring to the article ALKALESCENT. "This word signifies the tendency of bodies to become alkaline; and cannot "be properly applied to signify a slight degree of alkaline quality."

Page 49. *Notes, col.* 1, *line* 11. Instead of, "in ordinary distillations," read, "in the ordinary method of distilling wood, together probably with some of "its more fixed parts."

Page 55. *Notes, col.* 2, *line* 1. Instead of "this salt to," read, "the mineral to "the."

Page 62. *Notes, col.* 2, *line* 2. Instead of "by their different densities," read, "by fusion, according to their different densities, that is, the heavier metal "sinking below the lighter."

Ibid. line 25. Instead of "by their different densities," read, "by means of "their different densities."

Page 73. *Notes, col.* 1, *line* 9. Instead of "earth," read, "substance."

Ibid. col. 2, *line* 10. Instead of "The same," read, "An equal."

Page 75. *Notes, col.* 2, *line* 2. Dele "Hence."

Ibid. At the end of the note (*i*) add, "But as mercury has been found to rise "to a less height in barometrical tubes of iron than in those of glass, have "we not reason to believe that these metals possess a power of repelling each "other? *See the Hist. de l'Acad. Roy. de Sciences*, 1706."

Page 91, *line* 15. Instead of "flux," read, "resolvent."

Page 99. *Notes, col.* 2. *last line.* Instead of "cocoa," read, "coco."

Page 117. Instead of the paragraph beginning thus, "Some authors re-"commend, &c." read the following paragraph, as it is altered by the Author of the Dictionary.

"Several Chemists, amongst whom is Mr. Pott, have believed that the "solution of bismuth, which when well saturated, may be precipitated "by water, could not be precipitated by means of the marine acid, as those "of lead and silver may, and consequently that a corneous bismuth could not "be formed. But Mr. Rouelle, in his Memoir upon Salts, [*see Mem. de* "*l'Acad. des Sc.* 1754.] says, that after having precipitated from a well satu-"rated solution all the bismuth that he could by means of water, he obtained "a new precipitate by adding to the remaining liquor an equal quantity of "saturated solution of sea-salt, and by gradually mixing with these a quantity "of common water equal to four times the quantity of the two solutions. "This second precipitate is considered by Mr. Rouelle as a corneous bismuth.

"If this be the case, bismuth resembles lead in many of its properties, as "Mr. Geoffroy the Younger has shewn in the Memoirs of the Academy of "Sciences. Accordingly, some chemists have called bismuth, the *lead of the* "*semi-metals*."

Page 124. Instead of the paragraph beginning thus, "A chemist of Berlin "having, &c." read the following paragraph, as it is altered by the Author "of the Dictionary.

"Stahl relates in his *Three Hundred Experiments*, &c. No. 231, the manner "in which this blue matter was discovered. He says, that a manufacturer of "colors, called *Diesbach*, who usually prepared a lake of cochineal by mixing a "decoction of this substance with alum and green vitriol, and by precipitating "the mixture with a fixed alkali, being one day in want of fixed alkali, for "this purpose borrowed from *Dippel*, in whose laboratory he worked, some "salt of tartar, from which that chemist had several times distilled the animal "oil called *oil of Dippel*, and observed that the lake precipitated by means "of this alkali, instead of being red, was of a fine blue color. Dippel, to whom "Diesbach related this appearance, perceived that it must have been caused "by his alkali, and attempted to produce the same effects by giving the

same

"same quality to fixed alkali by an easier process. His attempts succeeded, "and from that time Prussian blue has been prepared."

Page 131. *Notes, col.* 2. *line penult.* Instead of " in," read, " of."

Page 138. *line* 20. Instead of " cacao, butter," read, " cacao-butter."

Ib. line 34. Dele " made."

Page 142, *line* 36, Instead of " that," read, " why."

Page 151, *line* 37. Instead of " ferruginous and sulphureous," read, " fer-"ruginous, sulphureous."

Page 181. *Notes, col.* 2. *line* 4. Instead of, " after a red heat has been gra-"dually applied," read, " after heat has been gradually applied till the cru-"cibles become red."

Page 216. *Notes, col.* 1, *line* 12. dele " also."

Page 226. *Notes, col.* 1. *line* 22. Instead of the sentence beginning with, " If "we mean by *element*, &c." read the following sentence: " But if we should "call every substance an *element* which we cannot analyse, then certainly many "other substances besides the above-mentioned four might be enumerated "as elements."

Page 253. Add the following *note*, referring to the *sixth line*.

" The method employed by Mr. Beaumé for obtaining a marine ether, "namely, by uniting the vapors of spirit of wine with those of marine acid, "has been successfully attempted by *Mr. Woulfe*. This ingenious chemist "condensed the united vapors of the spirit of wine, and of the marine acid, by "making them pass from the receiver through a tube into spirit of wine con-"tained in a bottle, and by making those which were not thus condensed pass "through another tube into more spirit of wine contained in another bottle. "By distilling and cohobating with slaked lime the liquors in the receiver, and "in the two above-mentioned bottles, he obtained a very subtle and pene-"trating ether. *See a description of the apparatus employed by Mr. Woulfe, and "many curious particulars concerning distillation, in the Philosophical Transactions, Vol.* LVII."

Page 254. Add the following *note*, referring to the *seventeenth line*.

" *Mr. Woulfe* describes an apparatus by which nitrous ether may be expediti-"ously obtained by distillation, with the heat only occasioned by mixing together "the nitrous acid and the spirit of wine. This distillation is performed in a "matrass with a high neck, to which is fitted a head, with a spout, commu-"nicating with the receiver by means of a long tube. Those vapors which are "not condensed in this receiver are conveyed from thence through a bent "tube into spirit of wine contained in a bottle; and if any vapors pass uncon-"densed through this spirit of wine, they are conveyed, through another bent "tube, into more spirit of wine contained in another bottle. The liquor "collected in the receiver, being slowly rectified with slaked lime, furnishes "very fine ether. The spirit of wine in which the vapors were condensed "contains so much ether, that this fluid may be separated from the spirit by "adding water. This spirit of wine is, by the operation, converted into very "good dulcified spirit of nitre. *See the Phil. Trans. Vol.* LVII.

Page 276. *Notes, col.* 1. *line* 39. Instead of, " when the flame has a con-"siderable diameter, as of a foot or eighteen inches, and," read, " when a

" vapor

"vapor of a considerable diameter, as of a foot or eighteen inches, is kindled, "and the combustion"

Page 278. *Notes, col.* 2. *line* 4. Instead of the sentence beginning, "They "are also convertible, &c." read, "By means of fixed alkali they may be fused "and vitrified: and when the quantity of fixed alkali is much greater than "that of the flints, the melted mass deliquiates by exposure to a moist air, and "becomes the liquor called *liquor of flints*, from which an earth may be preci-"pitated, by adding an acid. This earth, which must have been originally "the earth of the flints or sand employed, is now rendered soluble in acids, "and, as Mr. Pott says, is *calcareous*, or, as Mr. Beaumé affirms, is *argilla-"ceous*."

Page 294. Dele *Note (m)*.

Page 301. *Notes, col.* 1. *line* 5. Instead of, "contain nitre, sal ammoniac, "or common salt, alum, or some vitriolic salt," read, "contain nitre, alum, "or other vitriolic salt, and sometimes sal ammoniac or common salt."

The same page, Notes, col 1. *line penult*. Instead of the three successive sentences, the first of which begins thus, "Accordingly, in all the receipts, "&c." and the last of which sentences ends thus, "quickly plunges it in water," read the following: "This effect may be produced either by applying to the "metal an aqua fortis, by which any remaining mercury, or allay of copper, "or of other metals, that might discolor the gold, might be dissolved; or by "an aqua regia, which also would cleanse its surface, but, at the same time, might "dissolve the gold itself, if applied a time sufficiently long. Now, in all the "receipts which I have seen for this saline compound, I have always observed "nitre and alum, or some vitriol, together with other matters. From these "ingredients, by exposure to heat, an aqua fortis is evidently formed, the acid "of the alum or other vitriol disengaging the acid of the nitre. In several of "these receipts I have seen added to the above-mentioned salts some sal ammo-"niac or common salt. By this addition, an aqua regia is formed, which may, "as we have said, also cleanse the surface of the gold; but, as it may dissolve "part of the gold itself, even in the very short time during which it is applied, "the former compound, from which the nitrous acid only is disengaged, seems "to be preferable, and is now generally employed."

Page 336. *Notes, col.* 2. *line* 13. Instead of, "that it deliquiates," read, "that glass-gall deliquiates."

Page 310. *Notes, col.* 1, *line* 5. Instead of, "but those persons," read, "but this action of Moses is evidently related, and ought to be considered, "as miraculous, and therefore not explicable by natural means. As to those "persons"

Ib. col. 2, *line* 1. Instead of, "will," read, "they will."

Page 312, *line* 20. Instead of, "and so fixed," read, "and will become so "fixed."

Page 314. *Notes, col.* 2, *line* 3. After "fused," add a *comma*.

Page 478. *Notes, col.* 1, *line 6th from the bottom*. Instead of "coeval," read, "coeval, or nearly coeval."

Page 316, *line* 38. Instead of, "behind," read, backwards."

Page 324, *line* 15. Add the following *Note*. "This proposal is of a much "older date than the Memoir of M. de la Condamine."

Page

Page 361, *line* 20. Inſtead of, " citing," read, " exciting."

Page 409, *line* 23. Inſtead of, " method of friction," read, " method by " friction."

Page 425, *line* 15. Inſtead of, " By water," read, " With water."

Page 429. *Notes, col.* 2, *line laſt.* Inſtead of, " copper, iron," read, " iron, " copper."

Page 476. *Notes, col.* 1, *line* 4. Dele " up."

Page 479. *Notes, col.* 1, *line* 3. After " in a fluid ſtate," add, " and diſſolved " in water;"

Page 504. *Notes, col.* 2, *line 9th from the bottom.* Dele " alſo."

Page 552. *Notes, col.* 1, *line* 1. Inſtead of, " The petuntſe is improperly " ranked amongſt the claſs of earths called vitrifiable, becauſe, &c." read, " The petuntſe is ranked amongſt the earths called vitrifiable, improperly, as " I think, becauſe, &c."

Same page, col. 2, *line 3d from the bottom.* Inſtead of, " analiſed," read, " analyſed."

Page 555. *Notes, col.* 1, *line* 14. Inſtead of, " all of which are fuſible," read, " which are ſingly or jointly fuſible."

Page 591. *Notes, col.* 1, *line* 10. Inſtead of, " inexhauſted," read, " ex- " hauſted."

Same page, Notes, col. 1, *line* 24. Add, " But no inferences ought to be " drawn from experiments, which appear, from the author's own account, to " have been inaccurate, and not repeated."

Page 607. *Notes, col.* 1, *line* 4. Inſtead of, " or," read, " as."

Page 608. *Notes, col.* 1, *line* 9. Inſtead of, " unites ſo rapidly as to occaſion," read, " unites rapidly, and occaſions."

Page 742. *Notes, col.* 1, *line* 4. Inſtead of, " volatile, vitriolic," read, " vo- " latile vitriolic."

Page 815. *Notes, col.* 1, *line* 11. Inſtead of, " crown-glaſs," read, " flint- " glaſs;" *and line* 12, inſtead of, " flint-glaſs," read, " crown-glaſs."

Page [illegible], line 12. Instead of [illegible] read [illegible]

Page 400, line 25. Instead of "[illegible]" [illegible] by "[illegible]."

Page [illegible], line [illegible]. Instead of "[illegible]" [illegible]

[illegible]

Page [illegible]. Note, col. 1, line 3. [illegible]

Page 479. Note, col. 2, line 3. After "[illegible] a little [illegible] [illegible] dissolved in water."

Page 504. Note, col. 2, line [illegible]. [illegible] Dr. [illegible]"

Page [illegible], line [illegible]. Instead of "[illegible] [illegible] [illegible] [illegible]," read, "[illegible] [illegible] [illegible] [illegible] through the whole order [illegible] [illegible], as [illegible], beneath, &c."

Page [illegible], line [illegible]. Instead of "[illegible]," read, "[illegible]."

Page 555. Note, col. 1, line 11. Instead of, "all of which are fluids," read, "[illegible] [illegible] fluids."

Page 561, [illegible] line [illegible]. Instead of, "inexhaustible," read, "exhausted."

Same page, Note, col. 1, line 23. Add, "But no reference ought to the [illegible] experiments, which appear, from the author's own account, to have been inaccurate, and not repeated."

Page [illegible]. Note, col. [illegible], line [illegible]. Instead of "[illegible]," read, "[illegible]."

Page [illegible]. Note, col. [illegible], line [illegible]. Instead of "[illegible]," [illegible] "[illegible] [illegible] applying until [illegible]."

Page 743. Note, col. 1, line [illegible]. Instead of, "[illegible]," read, "[illegible] little vibrations."

Page [illegible]. Note, col. [illegible], line [illegible]. Instead of "[illegible]," read "[illegible] [illegible] glass," and [illegible] [illegible] "[illegible]," read, "[illegible]."

EXPLANATION

OF THE

PLATES.

PLATE I.

FIG. 1. A RETORT.
 A, Its belly or bowl.
 B, Its neck.
FIG. 2. Retorts of this form are called *English Retorts.*
FIG. 3. A GLASS ALEMBIC.
 A, The cucurbit.
 B, The head.
 C, The gutter within the head.
 D, The beak.
FIG. 4. A LONG-NECKED GLASS ALEMBIC.
 A, The body of the matrafs.
 B, The neck of the matrafs.
 C, The head of the alembic.
FIG. 5. A GLASS ALEMBIC *confifting of one Piece.*
 A, The cucurbit.
 B, The head.
 C, The aperture in the head.
 D, Its ftopple.
 E, The mouth of the cucurbit.
FIG. 6. A PELICAN.
 A, The cucurbit.
 B, The head.
 C, The aperture in the head with its ftopple.
 D, The two curved fpouts.
FIG. 7. A ROW *of* ALUDELS.

Fig 8. A Copper Alembic.

A, The body or cucurbit.
B, The neck.
C, The head.
D, The beak, noſe, or ſpout.
E, The refrigeratory or cooler.
F, Its cock.
G, The receiver.

Fig. 9. A Muffle.

Fig. 10. *A perpendicular ſection of a* Cuppel *or* Test. The curve line repreſents the bottom of the cavity that contains the metal. The plan or any horizontal ſection of a cuppel is a circle.

Fig. 11. An Ingot-Mould, into the cavities of which melted metals are poured.

Fig. 12. An Apparatus *for* Distilling, by which the vapors that uſually eſcape in the ordinary method of diſtillation, are condenſed by paſſing into water or ſome other fluid. This apparatus was invented and deſcribed by Mr. Peter Woulfe. *See the Phil. Tranſ. Vol.* LVII.

A, a retort. Inſtead of this retort, in the diſtillation of ſome ſubſtances, may be ſubſtituted an iron pot with a ſtone-ware head, the neck of which is to be inſerted into the receiver, as in the preſent Figure.

B, a receiver, with a neck, into which the neck of the retort is to be inſerted; and a ſpout at its bottom, through which the diſtilled liquor paſſes into the bottle C; and an opening in the ſide at D, into which one end of a tube bent at right angles is inſerted. The other end of this tube paſſes into a veſſel H, open at both ends, the lower opening of which is cloſed with a glaſs ſtopple. Through the upper mouth of the veſſel H, one end of another tube I, bent twice at right angles, paſſes, while the other end of this tube is inſerted into a bottle F, and immerſed in the water or other fluid contained in that bottle. The crooked tubes are fitted into the mouth of the veſſel H by means of a cork, in which are two ſemicircular notches, through which the tubes paſs, and by lute.

The tube which paſſes into the bottle F is fitted into the mouth of this bottle by means of a cork, in which is a ſemi-circular notch. This mouth of the bottle F is not cloſed with lute.

The vapor that is raiſed from the ſubſtance expoſed to heat in the retort paſſes into the receiver B, where part of it is condenſed, and flows into the bottle C, while the reſt of it paſſes through the tube at D, into the veſſel H. From this veſſel, the vapor that ſtill remains uncondenſed paſſes through the crooked tube I, into the water contained in the bottle F, by which it is all condenſed excepting ſome elaſtic air, which is extricated in almoſt all diſtillations. This elaſtic air riſes through the water, and eſcapes at the ſemi-circular notch of the cork in the mouth of the veſſel, which is therefore not accurately cloſed by lute.

In moſt diſtillations, a quantity of air is abſorbed at different times during the proceſs: and in this caſe the external air will preſs on the liquor in the bottle F, and force it through the tube I into the veſſel H, from which it may be taken by opening the ſtopple L.

The

The uſe of the veſſel H is to receive the liquor that may be thus raiſed from the bottle F, and to prevent it from paſſing into the receiver B, and from thence into the bottle C, where it might ſpoil the diſtilled liquor.

Mr. Woulfe, in the above-mentioned Philoſophical Tranſaction, relates ſeveral experiments made with this apparatus, from which the utility of this method of condenſing vapors by making them paſs into water, or ſome other fluid ſuited to the nature of the liquor diſtilled, appears.

Thus, by diſtilling twelve pounds of ſal ammoniac with quicklime and two gallons of water, he obtained eight pounds and a quarter of volatile alkaline ſpirit ſufficiently ſtrong to make eau de luce, which were collected in the bottle joined to the receiver; and upon adding two other gallons of water, he obtained ſeven pounds of weak volatile alkaline ſpirit. The water contained in the bottle F, which was ſix quarts, received an encreaſe of $2\frac{1}{2}$ lb. in weight from the vapor condenſed in it; and from experiments made to compare the ſtrength of the alkali thus condenſed by the water with that of the ſtrongeſt alkaline liquor firſt obtained, and which we have ſaid was fit for making eau de luce, it was found, that the ſtrength of the former was to that of the latter as 140 to 76: hence the quantity ſaved by this apparatus was nearly equal to five pounds of volatile alkali ſufficiently ſtrong for making eau de luce. Mr. Woulfe obſerved a ſingular difference betwixt the alkaline liquor collected in the bottle joined to the receiver, and that which was condenſed in the water in the bottle F, namely, that a conſiderable heat was excited by mixing the latter alkaline ſpirit, but not the former, with vitriolic acid.

Another experiment is related, of the diſtillation of twelve pounds averdupoiſe of common ſalt with an equal quantity of oil of vitriol diluted with 7 lb. of water. In this operation 9 lb. $5\frac{1}{2}$oz of ſpirit of ſalt were collected in the bottle C, and 6 lb. $12\frac{1}{2}$oz. of the ſame ſpirit were condenſed in ſix quarts of water in the bottle F. The reſiduum weighed 18 lb. 6 oz. Hence in this operation there was a loſs of eight ounces, or $\frac{1}{76}$th part of the whole, moſt of which probably was elaſtic air. The ſtrength of the acid condenſed in the water was found, by experiment, to be to the ſtrength of the acid collected in the bottle C, as 200 is to 109. Theſe vapors, condenſed in water, were found to be more concentrated when the diſtillation was conducted ſlowly than when it was haſtened. It appeared alſo, that the moſt concentrated portion of the acid of ſea-ſalt is the moſt volatile, and that its ſtrength was to that of vitriolic acid (the ſpecific gravity of which was to that of water as 24 to 13), as $44\frac{1}{4}$ to 31. Experiments alſo ſhewed, that this vapor of ſpirit of ſalt condenſed in water contained no vitriolic acid, although the ſpirit collected in the bottle C did contain ſome of that acid.

The ſame ingenious chemiſt formed a *marine ether* by applying the vapor of rectified ſpirit of wine to this very concentrated vapor of marine acid, and by condenſing the united vapors in ſpirit of wine. This he effected by a well contrived apparatus. The necks of two retorts, one of which contained the ſpirit of wine, and the other the ſea-ſalt and vitriolic acid, from which the marine acid was to be diſtilled, opened into one receiver, where the vapors met: from this receiver the vapors paſſed through a tube into ſpirit of wine contained in a bottle; and thoſe which were not there condenſed paſſed through another tube into ſpirit of wine contained in a ſecond bottle. By a further

 diſtillation

diſtillation and cohobation, with ſlaked lime, of the ſeveral liquors collected in the receiver and in the ſpirit of wine in which the vapors were condenſed, a very ſubtle penetrating ether was produced. Mr. Beaumé had tried to procure a marine ether by uniting the vapors of the marine acid, and of ſpirit of wine; but he failed, becauſe he did not uſe an effectual method of condenſing the vapors.

Mr. Woulfe did not find that much advantage was gained by this method of condenſing vapors in water, in the diſtillation of the nitrous acid from nitre mixed with vitriolic acid, excepting that thus the noxious fumes are prevented from hurting the operators.

He thinks his propoſed method of condenſation may be applicable to the diſtillation of vitriolic acid, the ſulphureous fumes of which are difficultly condenſible; to the rectification of phoſphorus, the vapor of both which ſubſtances ought to be condenſed by means of water; to the rectification or diſtillation of vitriolic ether, the vapors of which ought to be condenſed in ſpirit of wine; and, laſtly, to many other diſtillations.

PLATE II.

FIG I. *An* ESSAY *or* CUPELLING FURNACE. This figure and the following deſcription of this furnace are copied from *Cramer's Art of Aſſaying. See Dr. Mortimer's Engliſh Edition, p.* 75.

" The aſſaying furnace is made in the following manner: 1. Make with iron plates a hollow quadrangular priſm, eleven inches broad and nine inches high (*a a*, *b b*), ending at top in a hollow quadrangular pyramid (*b b*, *c c*), ſeven inches high, terminating in an aperture at top ſeven inches ſquare. This priſm muſt be cloſed at bottom with another iron plate, which ſerves as a baſis or bottom to it (*a a*). 2. Near the bottom make a door (*e*) three inches high, and five inches broad, that leads to the aſh-hole. 3. Above this door, and at the height of ſix inches from the baſis, make another door (*f*), of the figure of a ſegment of a circle, four inches broad at its baſis, and three inches and a half high in the middle. 4. Then faſten three iron plates on the fore-part of this furnace; let the firſt of them (*g g*), eleven inches long and half an inch high, be faſtened, ſo that its lower edge ſhall reſt againſt the bottom of the furnace, with three or four rivets, and in ſuch a manner, that there may be between the upper edge of the ſaid plate and the ſide of the furnace a groove ſo wide, as that the ſliders of the lower door (*k k*) may be put into it, and freely move backwards and forwards therein: theſe muſt be made of a thicker iron-plate. The ſecond iron-plate (*b b*), eleven inches long, three inches high, and perfectly parallel to the foregoing plate, muſt be faſtened in the ſpace between the two doors, in ſuch manner, that both the upper and the lower edge of it may form

form a hollow groove with the ſide of the furnace. One of theſe grooves, which is turned downwards, ſerves to receive the upper edges of the ſliders that ſhut the lower door (No. 2.) The other, that turns upwards, is to receive the inferior edges of the ſliders of the ſmall door above (No. 3). The third plate *(i i)*, which is like the firſt, muſt be rivetted cloſe above the upper door, in ſuch manner, that it may form a groove turning downwards, and contiguous to the upper edge of the upper door (No. 3.). 5. In order to ſhut both doors (No. 2. and 3.), you muſt adapt to each of them two ſliders made of iron-plates, that may move within the above-mentioned grooves (*k k*, *l l*); but the two ſliders belonging to the upper door (No. 3.) muſt have each a hole near the top; that is, one a ſmall hole one fifth part of an inch broad, and one inch and a half long *(m)*; and the other a ſemi-circular aperture, one inch high and two inches broad (*n*). Let, beſides, each ſlider have a handle, that they may be laid hold of when they are to be moved. 6. Moreover, let five round holes, one inch broad, be bored in the furnace, two of which muſt be made in the fore-part of the furnace (*o o*), two others in the back-part, all at the height of five inches from the bottom, but three inches and a half diſtant from each ſide of the furnace; and, finally, a fifth hole (*p*), at the height of one inch above the upper edge of the upper door (*f*). 7. In ſhort, let the inſide of the furnace be armed wirh iron-hooks, jetting out half an inch, and about three inches diſtant from each other, to faſten the lute with which the furnace is to be covered over within. 8. Let then an iron, moveable, hollow, quadrangular pyramid (*q*), three inches high, be adapted to the upper aperture (*d*) of the furnace, at the baſis ſeven inches broad, ending upwards in a hollow tube (*r*), three inches in diameter, two inches high, almoſt cylindrical, though ſomewhat convergent at top. This prominent tube ſerves to ſupport a funnel or flue, which is almoſt cylindrical, hollow, made of iron-plates, and two foot high, and which, when a very ſtrong fire is required, is put perpendicularly upon the ſhorter tube, in ſuch manner, that it enters cloſe into it, one inch and a half, or two inches deep, and may again be taken off at pleaſure, when there is no need of ſo ſtrong a fire. But this pyramidal cover (*q*) muſt beſides have two handles (*s s*) adapted to it, that it may be laid hold of, and thus be taken away or put on again: and that this, being put on the aperture (*d*) of the furnace, may not be eaſily thrown down, let an iron plate be rivetted to the right and left upper edge of the furnace (*c c*), and be turned down towards the inſide, ſo as to make a furrow open before and behind, into which the lateral edges of the cover may enter and be faſtened, and at pleaſure be moved backwards and forwards, whenever it muſt be put on, or moved. 9. Let a ſquare ledge, made of a thick iron-plate, be faſtened at top of the upper edge of the lower door (*e*); this is deſigned to ſupport the grate and the lute: but it muſt be made of two pieces, that it may be eaſily introduced into the cavity of the furnace. Thus you will have an aſſay-oven, which muſt afterwards be covered over on the inſide with lute. This you are to do as follows:

" That the fire may be better confined, and that the iron may not be deſtroyed by growing red-hot, the whole inſide of the furnace muſt be covered over with lute, one finger or one finger and a half thick. The lute fit for this is made of a maſs of clay mixed with ſand, and moiſtened with three or four times as much

much of ox-blood diluted with water *. But before you cover the inside of your furnace with this lute, you must first put within the furnace small iron bars, equal in length to the diameter of the oven, quadrangular, prismatical, half an inch thick, having their extremities supported by a square iron ledge, and three-fourths of an inch distant from each other; and you must fasten them so, that their flat sides may be oblique with regard to the transverse section of the furnace, and that the two opposite angles may look one upwards and the other downwards; the bars must not be laid flat, but edge-ways, by which situation you hinder the ashes of the fuel of the fire from being detained too long between the interstices of the said iron-bars, and from making an obstruction that would oppose the free draught of the air. The furnace being then covered over with lute, and dried up by a gentle heat, is at last fit for docimastical operations, and especially for such as must be performed in the assay-oven.

If then an operation is to be made in the furnace hitherto described, you must let through the four lower holes above described, of the furnace (*o o*) placed before and behind, and directly opposite to each other, two iron-bars one inch thick, and long enough that their extremities on every side may jut out of the holes a small matter. These serve to support the muffle and its bottom (*See* Plate I. Fig. 9.). You then introduce the muffle through the upper aperture of the furnace (*d*), and place it upon the above-described iron-bars, in such manner, that the open fore-side of it be contiguous to the inward border of the upper door (*f*). The fuel of the fire is introduced through the top of the furnace (*d*); the cover of which, on this account, must be moveable and not very heavy (*q*). The best fuel for the fire is charcoal made of the hardest wood, especially of beech, broken into small pieces of the bigness of an inch, wherewith the muffle must be covered over some inches high. We then reject larger bits of coals, because they cannot fall through the narrow interstices, between the sides of the muffle and those of the furnace, and cannot of course sufficiently surround the circumference of the muffle. Whence it happens, that there are on every side places void of fuel, and the fire is either not strong

* The best lute, and easiest to be had at London, is a sort of clay called Windsor loam, which must be mixt pretty stiff, and pressed into the inside of the furnace, first wetted with water; and when the clay begins to dry, it must be beat down close to the sides with a wooden mallet; then the unevenness and cracks filled up with fresh clay somewhat moister, so as to be made smooth and even with a trowel, and then left to dry gently; and if any cracks happen, they must again be filled up. *Note of Dr. Mortimer.*

Stourbridge clay, tobacco-pipe clay, or any other pure clay that is not fusible by fire, may be used for this purpose. But as fresh clay shrinks and cracks very much in drying, it ought to be mixed with an equal quantity or more of coarse white sand, or of burnt clay grossly powdered. Thus one part of Stourbridge clay, one part of coarse white sand, and one part of Stourbridge bricks grossly powdered, being well mixed together, make a good lute for lining the inner surfaces of furnaces. To prevent the iron plates of the furnaces more effectually from calcination, their inner surfaces ought to be covered with a coating of charcoal-powder formed into a mass or paste, with as much fresh clay and water as are sufficient for that purpose; and when this coating is dry, the above-mentioned lute may be applied. During the drying the lute ought to be daily beat with a mallet, that the spaces left by the shrinking of the clay may be closed, and the lute be rendered more compact.

enough

enough or unequal. But if, on the contrary, you uſe coals too ſmall, then a great part fall immediately through the interſtices of the grate into the aſh-hole; and the tendereſt particles of them turn too ſoon into *aſhes*, and by increaſing the heap of aſhes, obſtruct the free draught of the air, which is here greatly requiſite.

" A perfect management of the fire is moſt commonly neceſſary in the performing of operations in this furnace; therefore the reader muſt give attention to what follows: If the door of the aſh-hole (*e*) is quite open; and the ſliders of the upper door (*f*) drawn towards each other, ſo as touch one another in the middle of the door; and if, beſides, the cover (*q*), and the funnel adapted to its tube (*r*), is upon the top (*q*) of the furnace, the fire will be then in the higheſt degree poſſible; though, in the mean time, it is hardly ever neceſſary to put the funnel on, except in a very cold ſeaſon: but if, after having diſpoſed the furnace in the manner juſt deſcribed, you put red burning coals into the open upper door (*f*) of it, the fire is ſtill more increaſed thereby: however, this artifice is never, or very ſeldom, neceſſary. When you ſhut the upper door with only that ſlider that has a narrow oblong hole in it (*m*), then the heat becomes a little leſs; but it diminiſhes ſtill more when you ſhut the door with the other ſlider that has in it the ſemi-circular hole (*n*), which is larger than that of the firſt ſlider: nay, the heat again is leſs when you take away the funnel put at top of the cover: finally, the door of the aſh-hole being either in part or totally ſhut, the heat is ſtill diminiſhed, becauſe the draught of the air, ſo neceſſary to excite the fire, is thereby hindered: but if, beſides all theſe, you likewiſe open the upper door quite, then the cold air, ruſhing into the muffle, cools the bodies put under it, that are to be changed, to a degree never required in any operation, and ſuch as will entirely hinder the boiling of lead. If, during the operation, the fire begins to decay, or to grow unequal, it is a ſign that there are places void of coals between the ſides of the furnace and thoſe of the muffle; therefore, in this caſe, you muſt ſtir your coals on every ſide with an iron-rod, which is to be introduced through the upper hole (*p*) of the furnace, that they may fall together, and thus act in a proper manner and equally.

" However, you are to obſerve concerning the regimen of the fire juſt deſcribed, that though the *apparatus* is made with all the exactneſs mentioned, nevertheleſs the effect does not always anſwer it. The cauſe of which difference has moſt commonly its origin in the various diſpoſitions of the air; for as every fire is more excited by coals in proportion as the air, more condenſed, and more quickly agitated, ſtrikes them more violently (which the effect of bellows plainly ſhews); it thence appears, that in warm and wet weathers, when the atmoſphere is light, the fire muſt be leſs efficacious in furnaces; that likewiſe, when ſeveral furnaces, ſituated near each other, are burning at the ſame time, the fire is in part ſuffocated; becauſe the ambient air is thereby rendered more rare and lighter. The ſame effect is produced by the ſun, eſpecially in ſummer-time, when it ſhines upon the place where the furnace is ſituated. The atmoſphere, on the contrary, being heavier in cold dry weather, excites a very great fire.

" The heat of the fire acts the ſtronger upon the bodies to be changed, as the muffle put in the furnace is leſs; as the ſaid muffle has more and larger ſegments cut out of it; as the ſides of this muffle are thinner; in ſhort, as there are more

veſſels

vessels placed in the hinder part of the muffle; and on the contrary. In this case, when many of the conditions requisite for the exciting of fire are wanting, then indeed the artificer, with all his skill, will hardly be able to excite the fire to a sufficient degree, in order to perform operations well, in common assay-ovens, even though he uses bellows, and puts coals into the upper door of the furnace. For this reason, I have put the grate almost three inches below the muffle, lest the air, rushing through the ash-hole, should cool the bottom of the muffle, which happens in common assay-ovens; and again, that the smaller coals, almost already consumed, and the ashes, may more easily fall through the interstices of the grate, and the larger coals still fit to keep up the fire be retained. Finally, I have added the above-mentioned funnel, that the blowing of the fire being, by means of it, increased as much as possible, this might at last be carried to the requisite degree; for the fire may always be diminished, but not always be increased at pleasure, without the assistance of a proper *apparatus*."

FIG 2. This figure represents a furnace called an ATHANOR. *See* ATHANOR. This figure and the following description are copied from *Cramer's Art of Assaying*. " This furnace is used for the distillation of acid spirits, for calcinations, cementations, &c. As these operations require a long and constant fire, an athanor is useful, because it can contain as much fresh fuel as will keep up the fire for many hours together, and admits of a different, an accurate, and most constant regimen of the fire.

" Let then, 1st, a small square hollow tower *(a a a a)* be constructed of such *stones*, [or of bricks made of *Stourbridge clay*, or *Windsor loam*,] as may resist the fire; let the sides of it be six inches thick, and forming a square cavity within, of ten inches on each side *(b b b b)*. The height of it is determined according as it is to keep up the fire long, without any addition of new fuel: five or six feet are most commonly sufficient. 2. At the bottom of this tower make an opening *(c)*, six inches broad, and as many inches high; hang to it an iron door, being on every side one inch broader than the opening, and such as may shut it very close: for which purpose the external edge of this opening must be excavated all round in such manner, that it may form a groove one inch broad, into which the edges of the door may be received. 3. At the distance of ten inches from the bottom of the tower, put a grate *(d)*, made of prismatical, quadrangular iron-bars, one inch thick, and three quarters of an inch distant from each other: let also each of these iron bars be so situated with regard of the tower, that the two opposite acute edges of each may look perpendicularly, one downward, the other upwards, that, by this means, the ashes may easily fall into the ash-hole. 4. Make above this grate an opening circular at top *(e)*, six inches high, seven inches broad, that may, as well as the ash-hole (No. 2,) be open and shut with an iron-door. 5. Adapt to the top of the tower an iron cover *(f)*, exceeding the aperture of the tower all around two inches, and having a handle, wherewith it may be easily taken away, and put on again. Thus you are to make the furnace called in Latin, *furnus primarius*. 6. Then cut out in any side of the tower, for instance, in the left, an oblong square aperture, going up obliquely towards the outside *(g g)*, four inches and a half high, ten inches broad, having its inward

inferior

inferior edge, one inch and a half, or two inches above the grate (*d*); that by the intervening of this hole, the cavity of this tower may communicate with another immediately to be deſcribed. 7. Nearly over-againſt the ſame ſide of the tower, make a cavity with ſtones, whoſe inferior part muſt be a hollow priſm, (*h*, *h*, *h*, *h*,) ſix inches high, twelve inches broad, ending at top in a ſemi-cylindrical arch (*i*, *i*,) deſcribed by a *radius* of ſix inches; that by this means, the height of the whole cavity may be twelve inches in the middle. Let this anterior cavity be totally open, though, when requiſite, it is to be ſhut very cloſe with an iron plate (*k*, *k*,) whoſe inward ſurface is to be conſtructed in the ſame manner as is preſcribed for the ſliding door of the melting furnace, (FIG. 4,) and then luted two inches thick within. Moreover, let there be in the middle of this plate, a round hole, four or five inches in diameter, and let the circumference of this hole have an iron cylindrical border made to it, and prominent within; that by means of it, the lining of lute within may be ſupported, and kept from falling down eaſily. Let a notch one inch broad, and two inches deep, be made in the outward circuit of the aperture of this cavity, to receive the extremity of the plate that ſhuts the aperture. The hole of this plate, either is ſhut with a ſtopple, or ſerves to paſs the neck of the retort through. This plate likewiſe is faſtened with two bolts (*n*, *n*,), to be put horizontally with iron hooks (*o*, *o*, *o*, *o*,) driven into the wall near the edge of the aperture, ſo that one bolt may faſten the upper part of the plate, and the other the lower. 8. It is moreover proper, that the ſquare aperture (*g*, *g*,) through which the fire enters from the tower into the cavity hitherto deſcribed (No. 7.), may be ſhut and opened at pleaſure with an iron ſlider: for if this is not done, an exceſſive fire, employed ſometimes by an unexperienced hand, cannot be ſo eaſily checked. For this purpoſe, let a ſlit half an inch broad, and eleven inches long, be left in the wall that conſtitutes the upper part of the cavity (No. 7,), and is contiguous to the tower; ſo that it may exceed the length of the ſquare aperture (*g*, *g*,) a ſmall matter on every ſide, and reach before and behind into the ſmall groove, going down along the perpendicular ſides of the ſaid aperture, (*g*, *g*,) and retain the iron-ſlider to be put into it to keep it ſteady. However, let this iron-ſlider be ſix lines thick, eleven inches broad, and five inches high; and let a couple of ſmall iron-chains (*p*, *p*,) be faſtened on each ſide of its upper edge, wherewith the ſlider may be lifted up and let down again. Therefore, let a couple of ſtrong iron-nails be drove into the contiguous wall of the tower, perpendicularly over thoſe places in which the ſaid ſmall chains are faſtened to the iron-ſlider; that any of the links of the chains may be ſuſpended on them at pleaſure. Moreover, let the upper edge of the ſlit above deſcribed be entirely ſhut up with ſtones and cement, leaving only two ſmall holes through which the ſmall chains may be paſſed. On the left of this cavity (No. 7.), and at the diſtance of eight inches from the bottom of it, let a ſquare (*q*, *q*, *q*, *q*,) chimney or funnel be erected with *bricks*, three inches and a half in the clear, four foot high, and a ſmall matter convergent upwards, ſo that the diameter of it at top may be three inches. This funnel muſt be contrived to be ſhut cloſely with an iron-ſlider, having a handle to it (*r*, *r*,) which ſlider muſt move freely between a double iron ſquare frame faſtened in the walls of the funnel, at ſuch a height from the

 hearth

hearth as ſhall ſeem convenient to any artificer. 10. Below this chimney, let a ſquare aperture be made, like the foregoing (No. 6, *g*, *g*,), leading obliquely up to the bottom of another cylindrical cavity, (*u*, *u*, *u*, *u*,) which is eight inches deep, deſcribed by a *radius* of ſix inches, open at top, and there converging inwardly into a border one inch thick, and ſix lines broad, deſigned to ſupport an iron-pot. Likewiſe, cut in the anterior wall of this cavity, and at the upper part of its mouth, a ſegment two inches and a half deep, five inches broad, and ſtooping forward (*v*, *v*,) to receive the neck of the retort. 11. To this cavity (No. 10.) belongs an iron-pot (*w*, *w*,) eleven inches broad, and about nine inches deep, which muſt be encompaſſed with an iron ring (*x*, *x*,) one inch broad, and faſtened at the diſtance of one inch and a half from the upper end of the pot. Let a ſegment (*y*) be likewiſe cut off the upper edge of this pot, which ſegment muſt be four inches and a half deep, and five inches broad: the iron-ring juſt deſcribed muſt be bent all round the edges of this ſegment. 12. Over-againſt the aperture (*t*, *t*,) which communicates from the firſt cavity (No. 7.) into the ſecond (No. 10.), let another ſuch aperture (*z*) be made, two inches diſtant from the bottom of the ſecond cavity (No. 10.) perfectly like the foregoing (*g*, *g*, *t*, *t*,) and communicating obliquely upwards with a third cavity (1, 1, 1, 1,), like and equal to the ſecond cylindrical cavity (*u*, *u*, *u*, *u*,); that the fire may paſs from the latter into the former. 13. In the hinder part of the wall which makes the aperture juſt mentioned (*z*), let a chimney like the foregoing (*q*, *q*, *q*, *q*,), and of the ſame height (2, 2, 2, 2,), be erected, which may be ſhut with a ſlider like that (3). 14. Finally, on the left ſide of the third cavity let an aperture be made in the ſame manner (4), and like the foregoing ones (*g g t t z*); more remote however from the bottom of the cavity, without a paſſage at the other extremity, and communicating only with the cavity of the third chimney (5, 5, 5,), which muſt be erected in the ſame manner as the two foregoing ones (*q*, *q*, *q*, *q*. 2, 2, 2, 2,). Thus you will have a furnace very proper for a great many operations.

"We are now to ſpeak of the uſe of the *athanor* juſt deſcribed; and chiefly to mention, to what operations each of its parts ſerve in particular, and then how the fire may and muſt be governed in it. 1. You muſt put at the upper arched door (*e*) of the tower, a ſemi-cylindrical muffle twelve inches long, which muſt be introduced through the door: which for this reaſon muſt be of the ſame height and breadth as that door, three quarters of an inch thick, and open behind, being ſhut there by the hinder part of the athanor, as far as which it muſt reach. For this purpoſe, a *tile* muſt be ſet upon the grate (*d*) to ſupport the muffle. Let alſo this muffle have ſmall pieces cut out near its baſis, as common aſſay-muffles. You may put under this muffle your cement pots, or ſuch bodies as muſt be calcined with a long and violent fire; which can be done without a muffle, though not ſo neatly. 2. In the firſt chamber (*h*, *h*, *h*, *h*, *i*, *i*,) you may make the moſt violent diſtillations with an open fire: for retorts or large veſſels are introduced into it, after you have taken away the door (*k*, *k*, *k*,) and are put either upon the hearth itſelf of this chamber, or upon a particular ſupport of ſtone. But you muſt place theſe veſſels in ſuch manner, that their necks may eaſily paſs through the hole of the door, when

put

put on again: for which purpose, they chuse a support sometimes higher, sometimes lower, according to the different heights of the vessels. When afterwards the door is put on again, and fastened with both its bolts (*n*, *n*,), you must close with lute all the chinks which lie open about the neck of the vessel, and between the edges of the door and the entrance of the chamber. Then you apply to the neck of the vessel a cylindrical segment, ten or more inches long: by means of which the heat and the boiling vapors coming forth are gradually diminished; lest the recipient, which is always chosen a glass vessel, should split. The recipient, which must be united with the other orifice of the said segment, is supported either by the pavement, or by a certain kind of trivet, the construction of which is such, that it may be set lower or higher by means of three screws. 3. In this same chamber, instead of distillations, you may also make cementations, calcination, &c. in which case the round hole of the iron-plate may be shut and again opened with a stopple, that one may view the inside. 4. The second and third cavities (*u*, *u*, *u*, *u*. 1, 1, 1, 1,) serve chiefly to such operations as are made in baths [or beds] of *sand*, *ashes*, or *filings*. For instance, you put into each of these cavities a pot, (*v*, *v*,) and you stop with thin *lute* or with *sand*, which must previously be moistened, the slit between the iron-ring (*x*, *x*,) and the border of the cavity, upon which this ring rests. 5. Besides, you may also make in these two cavities, distillations by a reverberating fire, as well as in the first: only the fire is less violent in these, though sufficient to extract aqua fortis. You then take out the iron-pot (*v*, *v*,) and inverting it, you put it upon the mouth of the chamber; so that the brim of the pot, being the depth of one inch and a half above the iron-ring (*x*, *x*,) wherewith this pot is surrounded, may be received within the mouth of the cavity, and so that the segment cut in the pot (*y*) may, together with the segment cut out from the side of the cavity (*v*, *v*,) form a hole to let the neck of the vessel through. 6. All the *apparatus* being thus ready, you first introduce through the top of the tower (*b*, *b*, *b*, *b*,) a few burning coals; and put upon them some of the unkindled fuel of the fire; that the cavity of the tower may, according as it is thought necessary, be filled either entirely or only in part. Then with all speed you put upon it the iron-cover (*f*), and strew the border of this on the outside with *sand* or *ashes*, which you press gently with your hands: for if you should neglect this point, all the fuel contained in the tower would be kindled, and may endanger setting the house on fire.

We shall here annex a few general rules concerning the regimen of the fire in this furnace: for it is hardly necessary to explain all particulars, since practice will easily hint them to such as shall be ever so little acquainted with Chemistry. The fire may be made very strong, in the first chamber, (*b*,*b*,*b*,*b*,*i*,*i*,) when the door of the ash-hole (*c*), and the funnel (*q*, *q*, *q*, *q*,) of the chamber is quite open, and when the iron-slider suspended with chains (6. *p*, *p*,) does not hinder the fire from passing freely from the tower into this cavity. But the closer the funnel is shut, together with the door of the ash-hole, the more the violence of the heat diminishes: and this will be soon effected, if the iron-slider suspended with chains is let down in part: for the fuel contained in the tower burns at least as high as the space between the lower edge of the iron-slider and the grate (*d*). Observe besides, in those operations wherein the

round hole of the door is ſtopt with a plug, that when the ſtrongeſt fire is required, this hole muſt not be kept long open; becauſe the air ruſhing violently through it, ſoon cools the bodies put into the cavity. The operations above-mentioned may be performed in the ſecond and third chamber, in, and at the ſame time, and with the ſame fire, as they are in the firſt chamber; for the fire penetrates from the firſt cavity into the ſecond, and increaſes when the funnel (2, 2, 2, 2,) erected on it is opened: but before you do this, the funnel of the firſt cavity muſt be ſhut as much as that of the ſecond is opened. By the ſame means, you may hinder the fire, which ſerves for the operations made in the two firſt cavities, from going out through the funnels, and you force it out, on the contrary, through the third cavity and through its funnel (5, 5, 5,); that it may alſo act upon the bodies placed in that cavity. For the more the funnel erected upon the third cavity is open, the more one or even both funnels of the other two cavities muſt be cloſed: thence it is plain, that you cannot kindle the ſtrongeſt fire in the third cavity, unleſs there be one equally ſtrong in the other two; and that, on the contrary, the heat in the third cavity may be rendered leſs, by cloſing its funnel; though it be violent in the others. The ſame is true of the ſecond cavity, with regard to the firſt. Finally, you cannot make the ſtrongeſt fire under the muffle placed within the upper door *(e)* of the tower, unleſs you have an equal fire in the firſt cavity, which fire may conſequently be increaſed, by ſhutting the door quite againſt the muffle (*e*), and diminiſhed by opening it; there being mean while an equal heat in the firſt chamber, and in the following ones. The reſt will eaſily be learned by practice."

FIG. 3. A REVERBERATING FURNACE.

a, The aſh-hole door.
b, The fire place door.
c, *c*, *c*, *c*, Regiſters.
d, The dome or reverberatory.
e, The conical funnel.
f, The retort in the furnace.
g, The receiver.
h, *h*, Iron bars to ſuſtain the retort.

FIG. 4, 5, 6, 7, *and* 8, repreſent a MELTING FURNACE. Theſe figures and the following deſcription of this furnace are copied from *Cramer's Art of Aſſaying Metals.*

"The melting furnace is made of iron-plates, the inner ſurfaces of which are covered with lute. The cavity of it may be formed according to an elliptical mould. 1ſt. Make an hollow ellipſis, the focus's 12 inches aſunder, and the ordinate 5 inches long; cut it off in both its focus's, that it may aſſume the figure. (*Fig*. 4,). 2dly, Then make in this hollow body, and near its lower aperture, four holes, eight lines in diameter, and directly oppoſite (*c*, *c*,). 3dly, Then faſten two flat iron-rings *(d)*, almoſt one inch and a half broad, at both the upper and the lower inward edge of this oval cavity; and fill the inſide of it with ſmall iron-hooks, jutting out about ſix lines, and three or four inches diſtanc from each other. Theſe, together with the rings juſt mentioned, ſerve to faſten the lute. Thus will the body of the furnace be made: only you muſt add

add at the outside two iron-handles *(e, e,)* to be rivetted on each side of it, that it may be taken hold of and moved. 4thly, Then make the cover of the furnace, which may be formed like the part cut off from the ellipsis (See *Fig.* 5,). Let this have an opening *(b)* made in it, four inches high, five inches broad at bottom, and four inches at the top; and adapt to this an iron door hung on hinges to shut it close, and having at the inside a border fastened to it, answering exactly to the circumference of the door, and as prominent inwardly as the thickness of the lute to be applied to it requires: for the same purpose, let small iron-hooks be fastened to the inside of the door, which is intercepted by the said border. And lest this cover should be burnt within by the force of fire, you must cover the inside of it over with the same lute mentioned before for the assay-oven: therefore it must be likewise furnished with a ring and iron-hooks to fasten the lute; as was said before, when we spoke of the body of this furnace. Besides this, you must fasten two iron-handles *(Fig.* 5, *c, c,)* on the outside of this cover. Then a round hole must be made in the top of it, being three inches in diameter, prolonged into a hollow tube *(d)* almost cylindrical, and a few inches high, upon which the iron-funnel described may, in case of necessity, be put after the manner mentioned in the same place where we spoke of the assay-oven. 5thly, After this, the lining of both the body and cover of the furnace within is made in the same manner above-described. Moreover, you must make for this furnace two moveable bottoms, *viz.* one to receive the ashes, and admit the air; the other to serve for reductions. The first is made with an iron-plate, formed into a hollow cylinder, open at top, and to be shut at bottom with an orbicular iron-plate, as with a basis, five inches high, and of such a diameter, as that it may receive the inferior orifice of the body of the furnace *(Fig.* 4,) the depth of half an inch *(See Fig. 6.)*: therefore let an iron-ring *(c)* half an inch broad, be fastened on the inside of the said bottom, and at the distance of half an inch from its upper border, to support the body of the furnace put into it. Again, let this bottom have a square door, four inches high, and as many inches broad, that may be shut closely with a door hung on hinges, that you may by means of it increase or diminish the draught of the air, and thus govern the fire at pleasure. Then, on the left side of this door, and at about half the height of this bottom part, let a round hole *(d)* be made, one inch and a half in diameter, to admit the pipe of the bellows when need requires. Next to this, let another bottom part be made of the same matter and figure as the foregoing: let it be likewise of the same diameter, but two inches higher, so that it may be of the height of seven inches. Likewise let it have round it a like iron-ring below its upper border, to support the body of the furnace to be received in it. But let a hole two or three inches broad, and one inch high (*Fig.* 7. *c.*), be cut out just below the ring in the side of this bottom part; then let another round hole be made in the left side of this first hole, fit to admit the pipe of the bellows *(d)*. Further, let another round hole like the foregoing *(e)* be made on the right, and at the distance of one inch from the bottom: then let the whole inside of this bottom-part (the part above the ring excepted) be overlaid with lute, and a bed be made at the bottom, of a figure like that represented by the line (*f, g, h,*). The matter of which this is made

is

is common lute pulverised, passed through a sieve, and mixed with such a quantity of dust of charcoal, sifted in the same manner, so that the mixture being moistened and pressed down, may at least be lightly coherent. Of this matter pressed on the bottom of the bottom-part a bed is made, like a segment of a sphere, having in the middle a small cavity somewhat lower, and made extremely smooth, after the manner mentioned before when we spoke of large ash-vessels or tests.

This furnace is chiefly fit for fusions, which may be made in it with and without vessels. When you are to melt with a vessel, put the body of the furnace (*Fig.* 4.) upon the first bottom (*Fig.* 6.), that has a door to it to open on hinges; introduce two iron-bars through the holes of the furnace (*Fig.* 4. *c*, *c*); put upon them the iron-grate, which you are to introduce through the upper mouth of the furnace: then put in the middle of this grate a *brick* or square *tile*, very smooth every where, warmed, and perfectly dry: otherwise, the vessels put upon it, especially the large ones, are easily split by the moist vapors coming out of it in the operations. Let the height and width of this *stone* be a small matter broader and higher than the bottom of the crucible or pot to be set upon it; for if it were less high, the bottom of the vessel could not be sufficiently warmed; and if it were less broad, the vessel might easily fall from it: then put upon this *tile* the vessel containing the matter to be melted, and surround it immediately with coals on every side, which must be ranged according to the method prescribed before, in our description of the assay-furnace: then you govern the fire, by opening and shutting the door of the ash-hole (*Fig.* 6. *b*): you excite it by putting the cover (*Fig.* 5.) upon the body of the furnace; and if, besides, you put a funnel upon the cylindrical mouth (*d*) of this cover, the melting fire becomes still more violent: but if you moreover introduce the bellows through the hole of the bottom part (*Fig.* 6. *d*); and the joint of the furnace with the bottom part, and the door of the ash-hole, unless it can be shut very close, being exactly stopt with thin lute [*or Windsor loam*], the fire thus excited by the blast of the bellows is carried to the highest degree, and far surpasses that which may be made in a Smith's forge. Another advantage of this method is, that the vessels are not so easily broken, because the blowing of the bellows cannot affect them immediately, and because a fire perfectly equal is excited on every side. One may easily examine with this *apparatus*, how *stones* are affected by the violence of the fire only. Now, if you have a mind to perform any operation without a vessel, and with a naked fire; for instance, to melt and reduce the *calxes* or *scorias of copper*, *tin*, *lead*, and *iron*, or the ores of these metals; the body of the furnace must be put upon the other pedestal, having a bed in it (*Fig.* 7.). However, you must, before this, open with a knife the oblong hole (*c*), and the round one (*d*) of this bottom part, which are stopped with the lute sticking to the inside: then you apply at the round hole (*d*) on the left side of the bellows, in such manner that the nozzle of it, being directed obliquely downwards, may blow strongly against the bed (*f*, *g*, *h*): by this means, all the ashes that fall into the bed are blown away, and the strength of the fire determined to such a degree, that all the melted bodies that fall into the said bed remain in their state of fusion; and were it otherwise, the melted bodies would immediately wax cold, and

adhere

adhere in grains to the bed, whereas they ought to have melted into one *regulus*. The oblong hole in the fore-part of this bottom-part (*c*) ſerves to diſcover, by means of a poker, whether the matter in the bed be melted or not: it ſerves likewiſe to take away through it whatever might ſtop the bellows, and in ſome caſes to take away the *ſcoria*: then you put firſt coals into the furnace one ſpan high, and blow them well with the bellows, to make them burn, that the bed may be very hot before the matter to be melted is put into it; for if this is not previouſly done, the melted maſs ſeldom runs into a *regulus*, but remains diſperſed among the *ſcorias*, which ſoon grow hard. The bed being well heated, and freſh coals added to the fire, put into it ſuch quantity of the matter to be melted as cannot hinder the fire from being carried to the requiſite degree; which cannot be determined otherwiſe than by experience: again, put freſh coals, and upon them another quantity of the matter to be melted; they may be, like *ſtrata*, one upon another: but if the maſs, once melted, could not long ſuſtain the ſtrength of the fire, or if you had a mind to melt a greater quantity of matter than what can be contained in the bed, you muſt open the round lower hole (*Fig*. 7. *e*), that you may make a channel paſſing from that hole through the lute, and reaching to the ſmall cavity at the bottom of the bed (*g*): to this hole, at the outſide, apply an earthen diſh like the bed within, or any other proper recipient, ſurrounded with burning coals, into which the matter melted, running from the bed through the hole (*Fig* 7. *e*.), may be collected, as is repreſented by *Fig*. 8.

FIG 9. A tranſverſe ſection of a FURNACE in which SULPHUR is obtained *by diſtillation* from pyrites. In this furnace are placed ten or twelve tubes, one of which is repreſented in this ſection (7), lying acroſs the whole breadth of the furnace. Theſe tubes are open at both ends. At the larger end, the mineral, form which the ſulphur is to be diſtilled, is to be introduced; and then the opening is to be cloſed with an earthen ſtopper. The ſmaller end opens into a caſt-iron receiver (8), which receives the ſulphur that is diſtilled or eliquated. To prevent the crude mineral from paſſing into the receiver, a ſtar-like piece of baked earth is placed in the neck or ſmaller end of the tube, along with the ſulphur. Each furnace contains ten or twelve ſuch tubes. The length of the whole furnace is therefore evidently much greater than its breadth. The tubes are about four feet long, ſomewhat of a conical form, ſix or eight inches wide at their larger end, and three quarters of an inch at their ſmaller end.

1. The walls of the long ſides of the furnace.
2. The aſh-hole.
3. The grate made of bricks.
4. The fire-place.
5. The paſſage for the flame to the upper part of the furnace.
6. The two walls of the long ſides of the furnace which ſupport the tubes.
7. A tube placed acroſs the furnace.
8. A ſquare caſt-iron receiver.
9. Two holes in the roof of the furnace through which the ſmoke eſcapes. There are generally ten or twelve ſuch holes in different parts of the roof, ſome of which are occaſionally cloſed. *See a further deſcription of this*

this furnace, and of the operation of extracting sulphur, at the article SMELTING *of* ORES.

FIG. 10. This figure represents a transverse section of a FURNACE *for* PURIFYING SULPHUR *by* DISTILLATION. *See* SMELTING *of* ORES.

1. The foundation of the wall sunk under ground.
2. The side-wall.
3. The back-wall.
4. The ash-hole.
5. The grate.
6. The fire-place.
7. Two holes through which the smoke escapes.
8. The inner chamber of the furnace.
9. An iron cucurbit or pot.
10. A neck made of earthen-ware.
11. The vessel called the fore-runner.
12. A receiver.
13. A banquette or step raised to support the fore-runner. In this furnace, which is of an oblong shape, generally five or six such setts of distilling vessels are placed on each side.

FIG. 11. Represents a *quantity of ore piled up to be roasted.*

1. Two sides or faces of the pile. All the sides of it are covered with small ore.
2. The upper part of the pile, where holes or cavities are seen in which the sulphur of the ore is collected.
3. An opening where part of the pile has fallen down, and in which the sulphur is seen dropping down.
4. A plank to keep off the wind. *See* SMELTING *of* ORES.

FIG. 12. *A Section of the above Pile.*

1. The wood to make the fire.
2. Some charcoal for the kindling of the fire.
3. A channel formed by a wooden tube or pipe.
4. The large lumps of ore.
5. Small ore.
6. Finer ore, or dust of ore.
7. The substance called *vitriol*, that is, a half roasted ore powdered.

FIG. 13. Represents a longitudinal section of the FURNACE *at* RAMMELSBERG. *See a description of this furnace at the article* SMELTING *of* ORES *of* SILVER.

1. Foundation of the masonry in the ground.
2. A part of the back wall.
3. The tuyere.
4. Channels to carry off moisture.
5. The covering stone of these channels.
6. A bed of scoria.
7. The case or casse made o bricks.
8. A bed of clay.
9. A bed of sifted ore and substance called vitriol.
10. The charcoal which is thrown into the casse previous to the filling of the furnace with ore and fuel.

11. A

11. A mixture of fat earth and charcoal powder, with which the furnace is prepared or lined.
12. The hearth, with the trace.
13. The seat of the zinc.
14. The chemise.
15. The wall of one side of the furnace.
16. The middle wall of the furnace.

FIG. 14. Represents a longitudinal section of a REVERBERATORY FURNACE used in the *smelting of ores. See a description of this furnace at the article* SMELTING *of* ORES *of* COPPER.

1. The masonry.
2. The ash-hole.
3. A channel for the evaporation of the moisture.
4. The grate.
5. The fire-place.
6. The inner part of the furnace.
7. A bason formed of sand.
8. The cavity where the melted metal is.
9. A hole through which the scoria is to be removed.
10. The passage for the flame and smoke, or the lower part of the chimney, which is to be carried up to a height of about thirty feet.
11. A hole in the roof, through which the ore is thrown into the furnace. This furnace is eighteen feet long, twelve feet broad, and nine feet and a half high.

FIG. 15. Represents the upper plan of the FURNACE of which FIG 14. is a section.

1. The outer wall.
2. The draught-hole communicating with the ash-hole.
3. The door through which fossil coal is thrown into the fire-place.
4. The place where an opening is made to let the melted metal flow out of the furnace.
5. An opening through which the scoria is drawn off.
6. The bason made of sand where the metal lies.
7. The fire-place with an iron-grate.
8. A small wall between the fire-place and the area or bason, over which the flame passes.

FIG. 16. Represents the plan of a REFINING FURNACE for refining silver or copper. *See* REFINING *and* SMELTING *of* ORES *of* SILVER.

1. The pillars and walls of the furnace.
2. The bason of bricks, about eight feet in diameter.
3. The base of the vault of the furnace.
4. The great flame-hole, through which the metal to be refined is introduced.
5. Two holes for the bellows.
6. The hole through which the litharge runs off.
7. The grate on which the fire is made.
8. The door of the fire-place through which the wood and faggots used as fuel are introduced.

9. A bason for the reception of the refined copper, when that metal is refined in this kind of furnace.
10. A passage, which is to be occasionally opened to let the copper flow out.

Fig. 17. Represents a *longitudinal section* of the refining furnace, of which Fig 16. is a plan.

1. The masonry of the pillars and walls surrounding the furnace.
2. The channels for carrying off the moisture.
3. Other small channels which join in the middle of the bason.
4. The bason made of bricks.
5. A bed of ashes.
6. The hollow or bason in which the metal is melted and refined.
7. The great flame-hole.
8. The two openings for the entry of the tuyeres of the bellows.
9. The vault or dome of the furnace.
10. The fire-place.
11. The grate.
12. The draught-hole.
13. A hole in the vault, which, being opened, serves to cool the furnace.

Fig. 18. Represents a section of an Air Melting-Furnace.

1. The masonry.
2. The grate.
3. The ash-hole.
4. The ash-hole door.
5. The fire-place and fuel.
6. A crucible or pot containing the metal to be melted, standing upon a brick support, and covered with a tile.
7. A horizontal flue or passage through which the flame passes to the chimney (8). In this horizontal flue, a brick door opens laterally opposite to the test (10). By this means the same furnace serves both as a melting furnace for melting metals in crucibles, and also for the operation of testing or cupellation.
8. The chimney.
9. The mouth of the furnace through which fuel is thrown. This mouth is covered with a stone or an iron-plate.
10. A test surrounded by sand. The flame of the fuel strikes upon the metal contained in the cavity of this test.
11. An aperture through which the flame passes into the horizontal flue. The area of this aperture is from fourteen to twenty-two square inches.

The dimensions of this furnace may be suited to the quantities of metal to be melted. Generally, the area of the plan of the fire-place is from 64 to 144 square inches, that is, the length of each side of this area is from eight to twelve inches.

This complex furnace is useful to refiners of gold and silver: but where the testing part of the furnace is not wanted, as in furnaces for melting brass or steel, the horizontal flue (7) need not have any lateral opening or door. The length

length alſo of this flue may be leſſened, and its width made equal only to that of the aperture (11).

Fig. 19. This figure repreſents a vertical tranſverſe ſection of a Reverberatory Furnace invented by Schlutter for the proceſs called *eliquation*, by which ſilver is ſeparated from copper. *See the article* Eliquation.

1. The maſonry ſurrounding the furnace, excepting the front (9).
2. Two walls inclined to each other; covered with the two iron plates (7, 7.) that ſupport the metal (8) to be eliquated.
3. The way through which the lead and ſilver eliquated from the metal (8) flows towards a baſon made for its reception without the furnace.
4. The inſide of the furnace.
5. The aſh-hole.
6. The grate and fire-place, from which the flame paſſes towards the plates of metal (8), and eſcapes at a chimney in the end of the furnace moſt remote from the door of the fire-place.
7. Two plates of iron.
8. A cylindrical piece of metal compoſed of the copper containing ſilver, and of a ſufficient quantity of lead to cauſe the eliquation. The ſilver and lead thus eliquated from the copper, fall down into the cavity (3), and flow into a baſon on the outſide of the furnace. In this furnace ten or twelve ſuch cakes or cylindrical pieces of metal are placed parallel to each other.
9. The front of the furnace, through which the pieces of metal are introduced. This front is cloſed with an iron-door lined with clay, the length of which is equal to the length of the internal part of the furnace. This door may be raiſed by means of a chain and pulley, when the pieces of metal are to be introduced.

Fig. 10. Repreſents a vertical ſection of a Furnace *for* Smelting *of* Ores *of* Iron.

a, *a*, *b*, *b*, The height of the furnace above the level of the ground.

b, *b*, *c*, *c*, The part of the furnace below the level of the ground.

d, *d*, Shew the height where the great maſs of maſonry terminates, and the ſmaller maſs and thinner walls called *battles* begin.

d, *a*, *a*, *d*, One of theſe walls called *battles*.

e, The mouth or upper opening of the furnace.

f, *f*, A platform.

g, *g*, Sections of the ſmaller maſs of maſonry.

i, *i*, The beginning of the etalage. The ſpace *i*, *i*, *e*, is ſometimes called the *charge*.

k, *k*, The end of the etalage, and the beginning of the work.

i, *k*, 1, and *i*, *k*, 2, Are ſections of the etalage.

e, The bottom of the work.

m, The place where the melted metal and ſcoria flow out of the furnace. The ſcoria flows over the dame (*n*), and the metal flows at the bottom of the dame, and on one ſide of it, through paſſages made occaſionally in the bank of ſand and clay, with which this lower part of the front of the furnace is cloſed.

 n, The

n, The dame.

o, A workman opening a passage for the scoria over the dame, by means of a bar of iron.

p, *b*, A section of the arched space or embrasure, in the front of the furnace, under which workmen stand.

Q, The vault under the furnace.

R, R, Beams of wood to strengthen the walls of the furnace.

X, A workman throwing fuel and ore into the furnace.

Fig. 21. Represents a *plan of the above furnace* taken at a level with the tuyere.

k, The work.

m, *s*, The front of the furnace.

n, *n*, The bellows.

o, The tuyere.

p, *q*, The outer walls of the furnace.

r, *r*, Two iron bars or pokers placed upon the dame (*s*.)

m, The opening through which the metal flows.

m, *t*, The channel, and moulds made in a bed of sand, for the reception of the iron, when it flows out of the furnace.

x, *x*, The inner walls of the furnace.

Fig. 22. Represents a vertical section of a reverberatory furnace, used for the obtaining of Zinc from its ores. The construction of this furnace resembles nearly that commonly used for making of glass. It is a reverberatory vaulted furnace, the plan of which is circular. The hearth of this furnace is supported by arched pillars. On this hearth, six large pots, each of which is about four feet high, and contains some hundreds of pounds of ore of zinc, and of charcoal, or other inflammable matter, are placed in a circular row. Two of these pots (2, 2,) are represented in this section. A circular hole (4) is left in the hearth for the passage of the flame from the fire-place into the reverberatory, from which it escapes at a hole in the arch (9). In the head of each of these pots there is a hole for the introduction of the ore, which hole is stopped, during the operation, with a stopple of baked earth (1, 1,) and also there is a hole in the bottom, corresponding with a hole on that part of the hearth on which the pot is placed. Through each of these latter holes is inserted an iron tube (3, 3,) which is closely luted to the contiguous parts of the pot and hearth of the furnace. The pots are to be filled with the mixture of ore and coal, in the following manner: The stopple (1) of the mouth of a pot is to be removed, and into this mouth, one end of an iron tube or funnel is to be inserted, through a hole (8) in the vault immediately above the pot, while the other end of the tube or funnel remains without the furnace. Through this tube the mixture of ore and coal is introduced into the pot; then the tube is removed, the stopple is fitted and luted with fresh clay to the mouth of the pot, and the hole in the vault (8) is to be covered with a lid.

When the ore thus introduced is sufficiently heated, the zinc is revived or reduced by the inflammable matter mixed with it, rises in the state of vapor, which finding no other vent, passes down the tube (3). The lower end of this tube (3) being in contact with the external air is sufficiently cold to condense this vapor of zinc, and the zinc accordingly flows out of the lower end

PLATE. I.

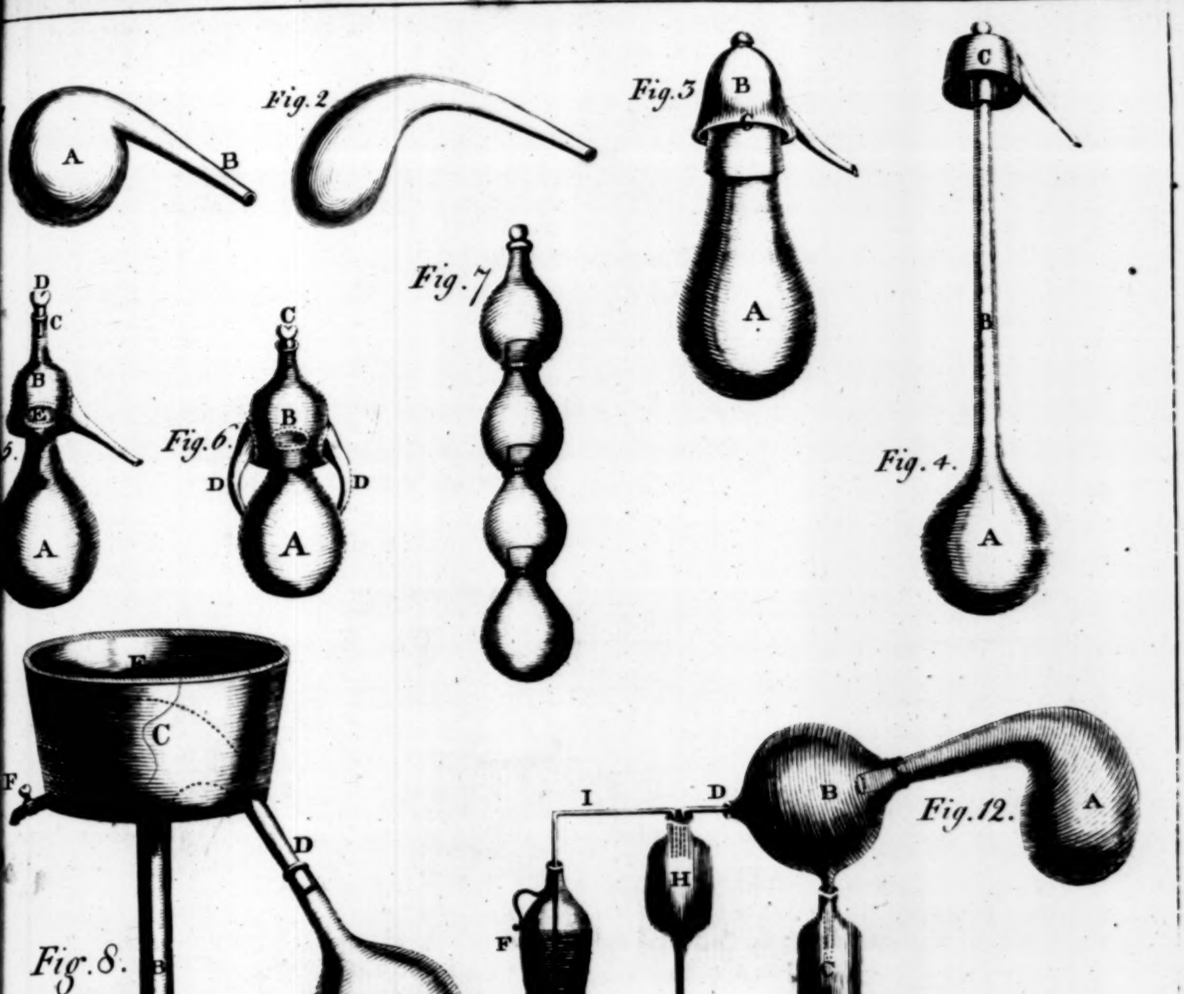
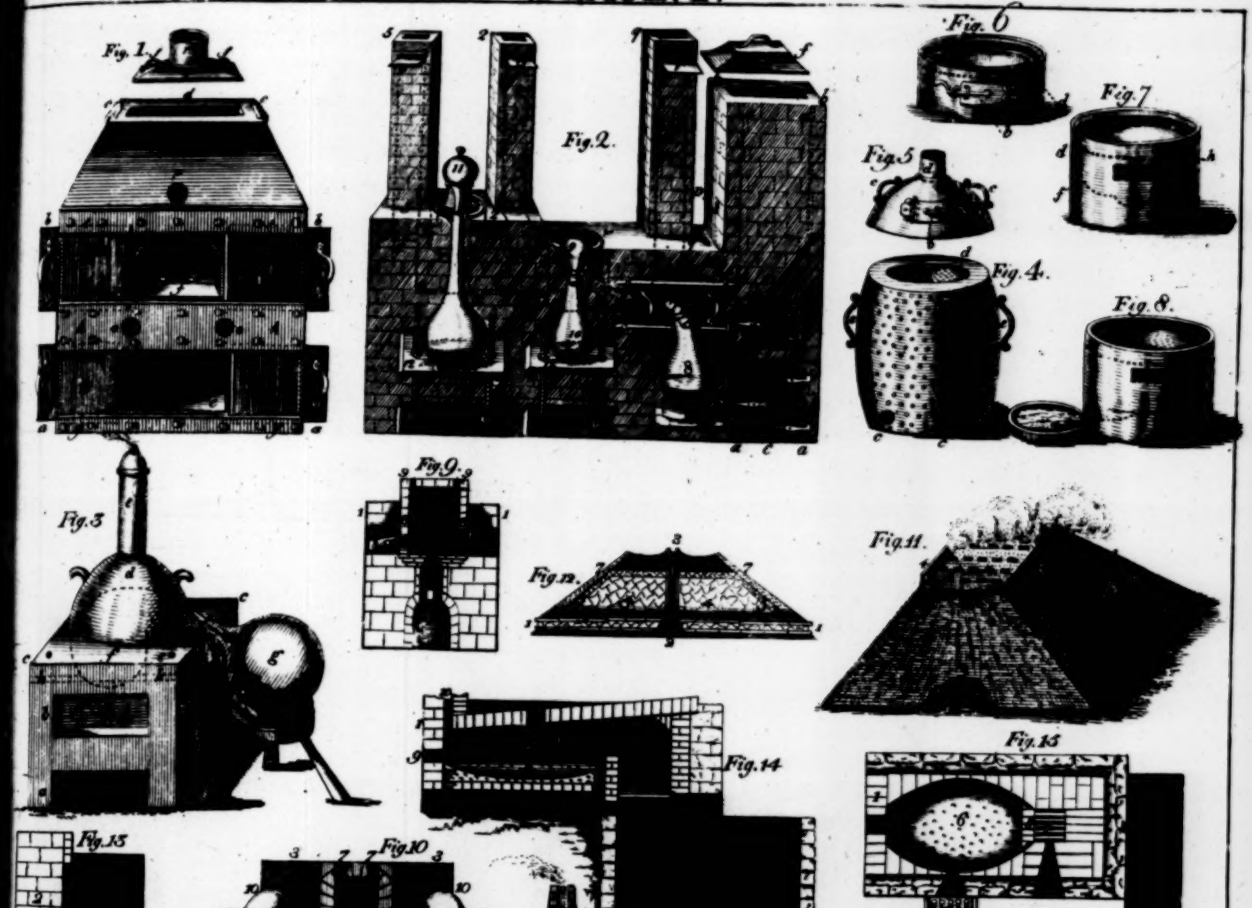


Fig. 2
Fig. 3
Fig. 4
Fig. 6
Fig. 7
Fig. 8
Fig. 9
Fig. 10
Fig. 11
Fig. 12
A
B
C
D
E
F
G
H
I
L
Westwood Sculp.

PLATE. II.



Westwood Sculp

of the tube in the ſtate of a melted metal, and falls or drops into a veſſel (7) containing water, where it becomes ſolid. Thus zinc is obtained from its ores by the kind of diſtillation called *per deſcenſum.* When the diſtillation is finiſhed, which is generally in three or four days, according to the heat applied, the nature of the ore, and other circumſtances, the tube (3) is removed, the reſiduum is thruſt out of the hole in the bottom of the pot by means of an iron bar or poker introduced through the opening of the vault (8) and the upper mouth of the pot. When the pot is emptied of the exhauſted ore, the tube (3) is to be replaced, freſh ore and coal are to be introduced in the manner above-mentioned, and the operation is to be repeated, without cooling the furnace or removing the veſſels.

This ſection is not taken from an exact menſuration, and therefore the proportions of the ſeveral parts are not accurately ſhewn. Nevertheleſs, as this method of obtaining zinc has not before been publiſhed, the preſent figure is ſufficient for the explanation of this ſingular proceſs.

EXPLA-

EXPLANATION

OF THE

TABLES OF AFFINITIES.

ALTHOUGH many of the affinities contained in theſe Tables are mentioned under the ſeveral articles of the ſubſtances to which they relate, in the preceding Dictionary, yet we thought it might be uſeful to place them in one view, as they are given by their authors *Geoffroy* and *Gellert*.

Each of theſe Tables conſiſts of a number of columns. At the head of each column is placed the ſubſtance, the affinities of which are to be compared with the ſeveral ſubſtances placed below it in the ſame column. Thus the firſt column of Mr. Geoffroy's Table contains the Affinities of *acid ſpirits*; the ſecond column contains the Affinities of *marine acid*, &c. The remaining ſubſtances in the firſt column, as *fixed alkali*, *volatile alkali*, &c. are thoſe, the affinities of which with acid ſpirits are to be compared together: and they are ſo diſpoſed, that the ſubſtance which has the ſtrongeſt affinity with *acid ſpirits* is placed neareſt to them, and the ſubſtance which has the leaſt affinity with acids is placed at the greateſt diſtance; while the ſtrength of the affinity of the intermediate ſubſtances may be known by their vicinity to the head of the column. Thus, acid ſpirits have a ſtronger affinity to fixed alkali than to volatile alkali, abſorbent earths, or metallic ſubſtances: alſo, they have a ſtronger affinity to volatile alkali than to abſorbent earths; and laſtly, they have a ſtronger affinity to abſorbent earths than to metallic ſubſtances.

Mr. Gellert has (in his original Table) inverted this order, placing thoſe ſubſtances at the greateſt diſtance, or at the bottom of the columns, which have the ſtrongeſt affinity with thoſe at the head of the columns. But as this difference in the order of the two Tables might create ſome confuſion, we have changed this diſpoſition of Mr. Gellert's Table, and have made it correſpond with that of Mr. Geoffroy, which is above-deſcribed.

According to the doctrine of affinities delivered under the article AFFINITY, of this Dictionary, any ſubſtance in any of theſe columns may be ſeparated from the ſubſtance at the head of that column by any of the intervening ſubſtances. Thus, according to the firſt column of Mr. Geoffroy's Table, if any *metallic ſubſtance* be united with an acid ſpirit, it may be ſeparated from that ſpirit, by

A TABLE OF THE SOLUTIONS OF BODIES, BY MR. GELLERT.

		A TABLE OF THE SOLUTIONS OF BODIES	BODIES NOT SOLUBLE BY THE SUBSTANCES PLACED AT THE HEAD OF THE COLUMNS IMMEDIATELY ABOVE THEM.
1.	Siliceous Earth	Hepar of Sulphur; Fixed Alkali; Borax; Calx of Lead; Calx of Antimony	
2.	Fluors	Hepar of Sulphur; Fixed Alkali; Borax; Calx of Lead; Calx of Antimony; Clay; Earth Calcareous; Earth Gypseous	Siliceous Earth
3.	Clay	Vitriolic Acid (partly); Hepar of Sulphur; Fixed Alkali; Borax; Calx of Lead; Calx of Antimony; Gypseous Earth; Calcareous Earth	Siliceous Earth
4.	Earth Gypseous	Acids (partly); Hepar of Sulphur; Fixed Alkali; Borax; Calx of Lead; Calx of Antimony	Siliceous Earth; Calcareous Earth
5.	Earth Calcareous	Vitriolic Acid; Nitrous Acid; Marine Acid; Acetous Acid; Hepar of Sulphur; Fixed Alkali; Borax; Calx of Lead; Calx of Antimony	Siliceous Earth
6.	Fixed Alkali	Phlogiston; Vitriolic Acid; Nitrous Acid; Marine Acid; Vegetable Acids; Zinc; Iron; Copper; Lead; Tin; Regulus of Antimony; Cobalt; Arsenic; Bismuth	Gold; Silver
7.	Volatile Alkali	Phlogiston; Vitriolic Acid; Nitrous Acid; Marine Acid; Acetous Acid; Zinc; Iron; Copper; Bismuth; Mercury; Silver; Gold	
8.	Acetous Acid	Phlogiston; Zinc; Iron; Copper; Lead; Bismuth	Gold; Silver; Tin; Mercury
9.	Marine Acid	Phlogiston; Zinc; Iron; Copper; Tin; Lead; Bismuth; Regulus of Antimony; Mercury; Arsenic	Gold; Silver (partly by the dry way)
10.	Nitrous Acid	Phlogiston; Zinc; Iron; Cobalt; Copper; Bismuth; Lead; Mercury; Regulus of Antimony; Silver; Arsenic; Tin (partly)	Gold
11.	Vitriolic Acid	Phlogiston; Zinc; Iron; Copper; Silver; Tin; Lead; Mercury; Bismuth; Regulus of Antimony; Arsenic	Gold
12.	Aqua Regia	Phlogiston; Zinc; Iron; Cobalt; Copper; Tin; Arsenic; Bismuth; Mercury; Lead; Regulus of Antimony; Gold	Silver
13.	Nitre	Phlogiston; Zinc; Iron; Copper; Arsenic; Lead; Tin; Regulus of Antimony; Cobalt; Bismuth	Gold; Silver
14.	Sulphur	Iron; Copper; Tin; Lead; Silver; Bismuth; Regulus of Antimony; Mercury; Arsenic; Cobalt	Gold; Zinc
15.	Hepar of Sulphur	Gold; Silver; Iron; Copper; Lead; Tin; Regulus of Antimony; Bismuth; Zinc; Cobalt	
16.	Cobalt	Copper; Iron; Tin; Zinc; Regulus of Antimony; Bismuth; Lead; Silver; Arsenic (partly)	
17.	Arsenic	Zinc; Iron; Copper; Tin; Lead; Silver; Gold; Regulus of Antimony	Bismuth
18.	Regulus of Antimony	Zinc; Iron; Copper; Tin; Lead; Silver; Bismuth; Gold	
19.	Glass of Antimony	Zinc; Copper; Tin; Lead; Iron; Silver	Bismuth
20.	Bismuth	Iron; Copper; Tin; Lead; Silver; Gold	Zinc
21.	Zinc	Copper; Iron; Silver; Gold; Tin; Lead (partly)	
22.	Lead	Silver; Gold; Tin; Copper	Iron
23.	Tin	Iron; Copper; Silver; Gold	
24.	Iron	Gold; Silver; Copper	
25.	Copper	Gold; Silver	
26.	Silver	Gold	
27.	Mercury	Gold; Silver; Bismuth; Zinc; Tin; Lead; Copper; Regulus of Antimony	Iron; Cobalt
28.	Glass	Calx of Lead; Calx of Cobalt; Calx of R. of Antim.; Calx of Gold; Calx of Silver; Calx of Copper; Calx of Iron; Calx of Bismuth; Calx of Zinc; Calx of Mercury	

A TABLE OF AFFINITIES BETWEEN SEVERAL SUBSTANCES, BY MR. GEOFFROY.

1. Acid Spirits	2. Marine Acid	3. Nitrous Acid	4. Vitriolic Acid	5. Abſorbent Earth	6. Fixed Alkali	7. Volatile Alkali	8. Metallic Subſtanc.	9. Sulphur	10. Mercury	11. Lead	12. Copper	13. Silver	14. Iron	Regulus of Antimony	Water
Fixed Alkali	*Tin*	*Iron*	*Phlogiſton*	*Vitriolic Acid*	*Vitriolic Acid*	*Vitriolic Acid*	*Marine Acid.*	*Fixed Alkali*	*Gold*	*Silver*	*Mercury*	*Lead*	*Regulus of Antimony*	*Iron*	*Spirit of Wine*
Volatile Alkali	*Regulus of Antimony*	*Copper*	*Fixed Alkali*	*Nitrous Acid*	*Nitrous Acid*	*Nitrous Acid*	*Vitriolic Acid*	*Iron*	*Silver*	*Copper*	*Lapis Calaminaris*	*Copper*	*Silver Copper Lead*	*Silver Copper Lead*	*Neutral Salts*
Abſorbent Earths	*Copper*	*Lead*	*Volatile Alkali*	*Marine Acid*	*Marine Acid*	*Marine Acid*	*Nitrous Acid*	*Copper*	*Lead*						
Metallic Subſtances	*Silver*	*Mercury*	*Abſorbent Earths*		*Acetous Acid*		*Acetous Acid*	*Lead*	*Copper*						
	Mercury	*Silver*	*Iron*		*Sulphur*			*Silver*	*Zinc*						
			Copper					*Regulus of Antimony*	*Regulus of Antimony*						
			Silver					*Mercury*							
	Gold							*Gold*							

by adding either an absorbent earth, or a volatile alkali, or a fixed alkali: secondly, if an absorbent earth be united with an acid spirit, it may be separated from that spirit, by adding either a volatile or a fixed alkali: and lastly, if a volatile alkali be united with an acid spirit, it may be separated from that acid by adding a fixed alkali.

To explain the use of these Tables still further, we shall give an instance of the affinities of *sulphur*, as they are expressed in Mr. Gellert's Table.

If sulphur be united with regulus of cobalt (*a*), with which, according to this Table, it has less affinity than with any of the substances mentioned in this column, and if to this compound arsenic be added; by sublimation the sulphur will be separated from the regulus of cobalt, and will be united with the arsenic, forming a sublimate called *orpiment*.

If to this orpiment an equal quantity of mercury be added, and if the mixture, after it has been well triturated, be exposed to heat in a retort, or other close vessel, the arsenic will be separated from the sulphur, and will form a white sublimate; while the sulphur and mercury will unite, and be afterwards sublimed together, forming a cinnabar.

If to this cinnabar a third part of regulus of antimony be added, and the mixture be exposed to heat in a retort, the mercury will be distilled, and the sulphur will remain united with the regulus, forming a compound similar to native antimony.

If to this artificial, or to native antimony fused in a crucible, half its quantity of bismuth be added, this semi-metal will unite with the sulphur of the antimony; while the regulus of the antimony will be separated, and form a distinct mass at the bottom of the crucible.

If this compound of bismuth and sulphur be melted with an equal quantity of silver, the bismuth will be separated from the sulphur, which will unite with the silver, forming a mass similar to the vitreous silver-ore.

If this mass, or the vitreous ore, be melted with half its quantity of lead, the silver will be separated from the sulphur, which will unite with the lead, forming a mass resembling the lead-ore called galena.

If this sulphurated lead be melted with tin, the lead will be separated, and the tin will be united with the sulphur.

In the same manner, the sulphur may be transferred from the tin to copper; and from copper to iron.

The affinities of bodies to each other, as they are laid down in the above Tables, or at least the separations and decompositions depending upon the differences of affinities, do not at all times take place; some of them requiring certain degrees of heat, dilution, and various other circumstances. Many instances do also occur in which the affinities of substances seem even to be changed by these different circumstances; and hence many exceptions have been found to the present Tables, some of which are real, and others only apparent. Thus, in the first column of Mr. Geoffroy's Table, metallic substances are placed as having a less affinity than absorbent earths with acids. Nevertheless, some

(*a*) In the Table it is marked *cobalt*; but Mr. Gellert evidently means the *regulus of cobalt*; for the ore properly called Cobalt, contains various substances, each of which has peculiar affinities. *See* COBALT.

instances

instances occur of earthy salts, as alum, being decomposed by means of metals, as of iron, zinc, and copper. Here therefore we find a real exception to this Table. Again, absorbent earths are placed as having less affinity than volatile alkali with acids. But the volatile alkali of sal ammoniac may be separated from the acid, by means of chalk or quicklime; which seems to shew, that some absorbent earths have a greater affinity with acids than volatile alkali. This alkali does indeed, when it is mild, precipitate a solution of any calcareous earth in any acid; and this experiment has probably induced Mr. Geoffroy to place these substances in their present order. But the above-mentioned precipitation is now known to be effected by what Mr. Macquer calls a double affinity. For the mild alkali, consisting of pure alkali and fixable air, is here to be considered as a compound: and when it is added to a solution of calcareous earth in any acid, the fixable air unites with the earth, to which it has a greater affinity than to the alkali, while the acid unites with the alkali. That this is the case, in the present instance, appears from the impossibility of precipitating this earth from the acid by means of a caustic volatile alkali, that is, an alkali which is not combined with fixable air. Many other instances might be adduced of the inaccuracies and defects of these Tables, and of the apparent variations from the general rules laid down in them; but as all chemical compositions and decompositions depend on the affinities of the substances employed, we cannot explain and correct these, without considering almost all the operations in Chemistry. Till other Tables more perfect be formed, these may be of considerable utility.

Directions *to the* Book-binder.

This Work is to be bound in two volumes. The first volume is to contain, 1. *The Preface by the Translator*; 2. The *Advertisement*; 3. The *Preliminary Discourse*; 5. The *Dictionary*, from A to N A, *p.* 440.

The second volume is to contain; 1. The *Dictionary* from N A to the end; 2. The *Tables of Characters and Affinities*; 3. *Plates* I. *and* II.